The Measurement of Understanding

FORTY-FIFTH YEARBOOK, PART I

Keep Your Card in This Pocket

THE FORTY-FIFTH YEARBOOK

OF THE

NATIONAL SOCIETY FOR THE STUDY OF EDUCATION

PART I
THE MEASUREMENT OF UNDERSTANDING

Prepared by the Society's Committee

WILLIAM A. BROWNELL *(Chairman)*, HARL R. DOUGLASS, WARREN G. FINDLEY, VERNER M. SIMS, AND HERBERT F. SPITZER

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EDITOR'S PREFACE

The present volume was proposed by Mr. Brownell at the meeting of the Board of Directors in October, 1943. It was the consensus of the Board that provision should be made for the preparation of a yearbook emphasizing meaningful outcomes of learning, and the general plan of the volume as outlined by Mr. Brownell was approved. It was agreed that early publication of this yearbook would be desirable, and Mr. Brownell was requested to serve as chairman of the committee. The chairman's recommendations regarding the organization of the committee were approved at the meeting of the Board in February, 1944, and the committee's proposals with respect to the content of the yearbook and the selection of associated contributors were approved at the ensuing meeting of the Board in May.

Measuring the results of teaching is a problem in educational procedure which must be dealt with in some fashion in all areas and at all levels of instruction. It has been the subject of continuing discussion and the object of unrelenting research since the turn of the century. There is an abundant literature which contributes to the enlightenment of teachers with respect to the purposes of educational measurement and the devices appropriate for use in measuring student progress toward particular educational objectives. The place of this yearbook in the literature of measurement is to be defined in terms of the impetus it will unquestionably give to greater emphasis in testing programs on methods of appraising the student's readiness for intelligent behavior in normal situations which engender a feeling of need for purposeful action. This is the neglected factor in evaluation programs generally, due to the prevalence of measuring devices for testing skills and factual information and the readiness with which the results of such testing may be interpreted. The products of learning which enable the individual to react intelligently to recognized needs are designated by the yearbook committee as "understandings." *The Measurement of Understanding* is designed as an aid to classroom teachers in the improvement of evaluative procedures by more effective use of measures of the status of the learner at different stages of progress toward an adequate understanding of the relationships involved in life situations. To this end, the yearbook is replete with illustrations of test materials appropriately designed and adapted to the requirements of different subjects of instruction.

NELSON B. HENRY

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CHAPTER I

INTRODUCTION: PURPOSE AND SCOPE OF THE YEARBOOK

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Originally this yearbook, *The Measurement of Understanding,* was entitled "The Measurement of Meaning." Being unsatisfactory for a number of reasons, this first name was abandoned successively in favor of "The Measurement of Meaningful Learning," "The Measurement of Learning," and "Measuring the Higher Mental Processes in Education"—all before the present title was adopted. *The Measurement of Understanding* may or may not define the purpose and scope of the yearbook better than one of the previous titles; but this rehearsal of the committee's attempts to name its product should serve two ends. In the first place, it should illustrate the difficulty of arriving at precise and unambiguous terms in the area under consideration. In the second place, it should reveal, even if somewhat negatively, the nature of the task which the yearbook committee set for itself.

Both the word "measurement" and the word "understanding" are variously employed. There will be some who object to the broad connotation here given "measurement." Such persons restrict the term so as to be as nearly analogous as possible to measurement in the physical sciences, where the units employed are clearly definable, identifiable, and quantitative. In this yearbook, on the other hand, the term is used with a much wider meaning, perhaps in the sense in which other writers use "appraisal" or "evaluation."

The point at issue transcends the question of terminology. Evidences of learning abound on every hand, provided that teachers are alert to their presence and to their significance. Some of this evidence is susceptible to measurement by means of paper-and-pencil tests. Other evidences of learning are best assessed in other ways, for example, by examining pupils' work products, by questioning pupils in the classroom and in conferences, and by observing their behavior in and out of school. Such opportunities to evaluate learning are too im-

portant to be neglected. Accordingly, one purpose of the yearbook, as is clearly pointed out in chapter iv and as is illustrated by the numerous practical suggestions in the chapters of Section II, is to encourage teachers to make more use—and to make more confident use—of non-test situations. Those who object to "measurement" as being inappropriate when evidence of learning is obtained by procedures other than objective testing may substitute their own word. The term does not matter; the securing of such evidence does matter.

So much for "measurement"; now for "understanding." "Meaning," "meaningful learning," "the higher mental processes"—all these expressions as used in suggested titles for the yearbook have one point in common: they show that from the outset the yearbook was designed to deal with a particular group of educational outcomes. These outcomes are not factual knowledge and mechanical skills; instead, they are those which are comprehended in the term "understandings." Unfortunately, the word "understandings" is not readily defined (see chapter iii); but even so, it clearly implies something more than the ability merely to recall facts or the ability to use skills in precisely the situations in which they have been learned. It is with measurement of this "higher" type of educational outcome or mental process that this yearbook is concerned.

There is need for a volume on the measurement of understanding. Altogether too commonly understandings are disregarded in evaluation (and in teaching) in favor of outcomes which are more easily measured (and achieved). The techniques for measuring factual knowledge and simple skills are fairly well worked out, and these techniques are known to teachers and are fairly well administered by them in the classroom. Indeed, it might almost be said that they are too well administered; for, having measured factual knowledge and skills, teachers may feel that they have measured all that needs to be measured. In these circumstances—and they are by no means rare—there is small likelihood that understandings will be evaluated.

This yearbook, then, deliberately omits consideration of the measurement of factual knowledge and skills. This omission is not to be misinterpreted; it should suggest no intention to belittle these educational outcomes. It is obvious that many facts and skills are essential to facility and efficiency in any subject-matter area. To spell, the child must learn the arbitrary symbols which we employ to stand for letters; to count, he must learn the number names and their order by establishing arbitrary associations. In geography, he must know that there are forty-eight states in the Union, whether or

not there is any reason for this particular number. In chemistry, he must learn the names and symbols for elements and compounds. There is no gainsaying the educational importance of such factual knowledge or of the many simple skills which could be enumerated. Such educational outcomes are disregarded in this yearbook, not because they are worthless, but for a quite different reason: Understandings are also of critical significance, and teachers are not so familiar with the means of teaching them. Teachers must learn how to evaluate both status and progress in understanding, and they must establish the habit of evaluating them. Until they do so, they will probably continue to teach understanding incompletely, so closely related are the processes of teaching and of measurement (see chapter ii).

There is of course some danger in regarding understandings as educational outcomes. This danger arises when understandings are made the ends or goals of instruction and of learning. They should not be so conceived. There is no justification for teaching understandings for the sake of the understandings themselves. On the contrary, understandings are desirable to the extent that they function in life, to the degree to which they make for more effective living. Such is the view of understandings which is held by the yearbook committee and which, it believes, is held by most modern educators. This caution should be enough to prevent a misinterpretation of the fact that in this volume attention is given exclusively to understandings.

All that has been said thus far should emphasize the essentially practical character of the yearbook. Those who are in search of abstract, scholarly dissertations on the theory of evaluation or of startling new techniques of measurement are forewarned that these will not be found in the present volume. This yearbook is addressed to the classroom teacher. Its purpose is to make available to the teacher some of the better devices and procedures which have been developed to measure understandings—to make them available as models or patterns which he can alter and adapt to his own needs.

As a matter of fact, the ultimate purpose of the yearbook is the improvement of classroom instruction. The immediate purpose, the improvement of evaluation, is regarded as a means to the more remote end. The virtue of devoting this yearbook to the measurement of understandings rather than to the teaching of understandings is that this approach is more definite and concrete. The many specific illustrations of methods for measuring understandings presented in

Section II should have the effect of calling teachers' attention to educational outcomes which they are now underemphasizing. When teachers measure understandings more extensively and more thoroughly, they will teach understandings better. In turn, when they teach understandings better, they will inevitably gain new insights into procedures to evaluate understandings. The relationship between teaching and measurement may be thought of as reciprocal—reaction and counter-reaction.

To achieve its practical purpose or purposes, theory is held to a minimum, and the largest possible amount of space is devoted to illustrative procedures for measuring understandings. Section I, "Theoretical Considerations," consists of three short chapters. Their titles reveal their functions fairly well: chapter ii, "The Importance of Teaching for Understanding"; chapter iii, "The Nature of Understanding"; and chapter iv, "Obtaining Evidence of Understanding."

At first glance chapters ii and iii may seem to be out of their logical order, on the ground that "understandings" must first be defined before they can be profitably discussed as outcomes to be developed and to be evaluated. The present order likewise has its logic. Without careful definition the term "understanding" is already familiar enough to the reader of this volume to warrant use of the word as in chapter ii, which through stressing its educational importance points up the need for the present yearbook. The more technical consideration of the term is, therefore, postponed to chapter iii. In this position it raises no needless difficulties for the reader and provides the basis for the practical suggestions of chapter iv, on the measurement of understandings.

The greater share of the volume is given to Section II, and properly so. Separate chapters are assigned to the measurement of understandings in different subject-matter areas. All the major areas are treated, but because of space limitations it has been necessary to omit chapters in a few areas, for example, in the commercial subjects and in the foreign languages. These omissions are regretted, but teachers in such areas are not left without help. The teacher of the commercial subjects, for instance, will find much of value in the chapters on mathematics, on the social studies, and on the language arts. Similarly, the teacher of foreign languages can study with profit the chapters on the language arts and on the social studies.

Attention is directed to the organization of the chapters of Section II. In most cases the chapters comprise two sections. Each starts with an authoritative list of outcomes in a given subject-matter area.

Since this yearbook is concerned exclusively with the measurement of understandings, only outcomes which involve understandings are included. The second section of the chapter consists of sample devices and procedures for measuring understandings, many of these samples being keyed to the foregoing list of outcomes. Wherever possible, generally accepted lists of outcomes have been utilized; that is, lists which have been sponsored by responsible and representative associations or agencies or committees. Wherever such lists were not to be had, chapter committees have undertaken the task, by no means an easy one, to formulate outcomes from such semiauthoritative lists as they could find. The intent was to prevent the inference that any chapter has stemmed from a biased point of view. Stated positively, the intent was to secure lists of outcomes which as nearly as possible will be approved by all schools of thought within each subject-matter area.

Section III, consisting of a single short chapter, concludes the yearbook. Its title, "Next Steps," and its content are intended to suggest that the last word has yet to be said about the measurement of understandings. As a matter of fact, more is now known about this problem than appears in the discussion and in the practical procedures of Sections I and II. It seemed best not to draw upon all this knowledge at these earlier points, but to reserve comment thereon until the last chapter. If teachers will move forward to the limits represented in Sections I and II, they will have made a tremendous advance. The "next steps" of Section III may then safely be left to the future.

The committee in charge of the yearbook—and the profession at large—are greatly indebted to the writers of the chapters of Section II. In every sense of the word these individuals have made the yearbook, for it is their product rather than the chapters devoted to general considerations which will influence classroom practice with respect to the measurement of understandings.

The yearbook committee selected the chairmen of the committees for the various chapters of Section II and supplied them the blueprints for the job. The execution, by far the more difficult part of the job, was left to the chapter chairmen and the collaborators whom they chose. Both chapter chairmen and committee members had to have certain qualifications. First, they had to be competent in their subject-matter areas and to be known for their competence. Second, they had to be familiar with, and interested in, the problem of measuring understandings. Third, they had to possess a rare degree of ingenuity

and originality in order to capitalize on their first two qualifications and to formulate the needed types of measurement devices and procedures. For financial reasons the chapter committees could hold no group meetings, but they overcame this handicap effectively. Through correspondence they worked together as units, so that each chapter represents the co-operative industry of some of the best minds in the country. It would be a poor reward indeed for their enlightened and unselfish efforts if the measurement of understandings in the classroom should not be greatly changed for the better.

SECTION I

THEORETICAL CONSIDERATIONS

CHAPTER II

THE IMPORTANCE OF TEACHING FOR UNDERSTANDING

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"Knowledge is power" is a familiar maxim, but it is not always a sound maxim. It is not a sound maxim when "knowledge" is made to mean merely the possession of a great many facts. Such "knowledge" affords one little "power." To have real power in the sense of the maxim one must know, besides the facts themselves, the relationships which link them together; and one must know when and how to use them. In a word, the kind of "knowledge" which makes for "power" is that which includes understanding.

We were told long ago that "understanding passeth knowledge." Today the man in the street recognizes full well the distinction between knowledge as *information* and knowledge *with understanding*. He cares little for walking encyclopedias. On the other hand, he admires those who can put their knowledge to work. He realizes that effective living is dependent, among other things, upon a large store of understandings. He gives evidence of this feeling in the phrases he uses to identify the competent individual: "He knows his business," and "He knows his stuff." These statements, it should be noted, are equally applicable to the competent farmer, grocer, baseball pitcher, teacher, and school pupil. The man in the street employs other expressions, too, which testify to the worth he attaches to understandings as prerequisites for effective living: "He has the idea all right."

"Do you get the sense of it?" "I savvy." "Catch on?" "I don't see it." "Do you follow me?"

The man in the street is not deluding himself when he places value on understandings. There is good reason to prize them. Without understandings both the range and the quality of our adjustments are greatly limited, for without them we can react only to familiar situations and then in a routine manner. It is, of course, possible to conceive of a life composed of nothing but such situations, in which case understandings would need to be neither full nor numerous. But few of us live such lives, and few of us would want to. Typically, life steadily confronts us with relatively unfamiliar situations, and we must be able to meet them confidently and intelligently. We cannot do so if we are equipped only with barren facts and formal skills. Our only insurance for rich and satisfying lives lies in a stock of understandings. Understandings, then, are not luxuries but practical necessities.

Perhaps an illustration will serve to give meaning to this generalization. We may be called upon to make a decision upon such national policy as compulsory military training. Or, the demand may be less severe, and we may be called upon only to have an opinion (not simply a prejudice) about the worth and functions of such agencies. In either case understandings are obviously essential. To increase our understanding we may read. Even so, we are again at the mercy of understandings, for without them our reading will accomplish little. As our eyes focus upon successive words and word groups, we undergo a series of experiences. The nature of these experiences, their richness, their accuracy, their satisfyingness, and their usefulness—all these depend upon the understanding which we can bring to the symbols we read.

Little is to be gained by laboring the point that understandings are of paramount importance in life; all experience shows that they pay dividends. As individuals we early learn this lesson. For this reason we, ourselves, seek to grow in understandings, and we approve and reward evidence of understanding in others. For this reason, too, we look to the school to develop understanding in our children, as one of its major responsibilities.

Teaching for Understanding

Neglect of Understanding in Traditional Instruction

The school has not always given understanding its due emphasis. Probably there have always been teachers who have recognized the

importance of understanding and have consistently striven for this goal in their teaching. And probably there have always been teachers who stressed understanding part of the time. Still, the statement is true that, traditionally, teaching methods have neglected or minimized understandings as learning outcomes. Instead, they were designed primarily to develop the ability to recite words or to perform skills in response to the specific cues of classroom questions and commands. The learning which took place was slight in amount; too often it was superficial and artificial; and it was relatively useless. It could be applied neither to other segments or units of knowledge nor to life needs, and it was soon forgotten. The learning was a learning of words.

The foregoing criticism may seem unduly harsh; so, suppose we consider a few concrete illustrations. To start with arithmetic, instruction was concerned chiefly with getting pupils to say the number combinations as bare facts, to acquire skill in abstract computation, and to develop ability in so-called problem solving (the last named being restricted to the artificial, predetermined situations of textbook problems). Little attention was given meanings, either mathematical or social. It was not considered essential that children see sense in what they learned or that they be able to apply what they learned to practical, personal ends. On the other hand, the dignity assigned to purely formal skill is illustrated by the then accepted marks of distinction—the ability to compute cube root and to perform involved paper-and-pencil operations with unreal fractions and with absurdly complex denominate numbers.

In the social studies emphasis was placed too exclusively upon learning and reciting facts of history, geography, and civil government—the names and locations of cities, rivers, and mountains, facts of chronology in history, duties and powers of governmental agencies, and the like. Cause and effect relationships were seldom pointed out, except in neat summaries which could be memorized. Few children saw in geography the story of man's evolution as a social being, able and anxious to live richly in larger and larger self-governing groups.

In reading, learners were required to pronounce words as given on the printed page with what passed for appropriate inflection, tempo, and emphasis. Reading was not viewed as a thought-getting process. Rather, the aim seemed to be the development of mechanical proficiency in the recognition of the printed word, and it was assumed that this proficiency would operate satisfactorily however and whenever reading was engaged in. As a consequence, too few children acquired the techniques (or even realized the necessity) of understand-

ing what they read, together with its meanings, its significance, and its potential applications to life experiences.

In biological science, students spent their time in learning to recite the names of the bones of the body, simple descriptions of bodily systems, and the names and classes and parts of plants. Direct contacts with real objects being few, they seldom were able to see in their own bodily structures and functions the facts and relationships and processes which supposedly they had acquired in mastering the verbalism of physiology. Instruction in physics and in chemistry was likewise barren of practical consequence; here again empty facts and mechanical skills, including the few acquired in the formalized laboratory, were the content of learning, and memorization was the method of learning.

Even the teaching of English gave greater attention to mechanical considerations than to matters of understanding. If when asked, "What is a sentence?" a youngster could reply, "A sentence is a group of words which expresses a complete thought," he was considered to have learned the nature of the sentence—this in spite of all kinds of evidence in his oral and written English that he could not formulate or recognize good sentences. And the long exercises in diagramming, intended to teach the nature of sentence structure, left most children untouched. They failed in correct diagramming and in correct writing for the same reason, namely, a lack of the essential but untaught understandings.

In the area of esthetic experience, basic understandings (appreciation is one form of understanding) were likewise withheld. The pure joy with which primary-grade children attempted to express themselves in poetry, or in music, or in graphic arts, for example, was soon changed, under inappropriate instruction, to hypocrisy and conformity and to indifference or to open dislike. It was the rare upper-grade or high-school student who engaged in these activities without embarrassment. Happy, creative self-expression, instead of being nurtured wisely, was sacrificed to techniques which, unintelligible in themselves, had to be mastered if the teacher was to be satisfied.

A dreary gallery of gloomy pictures? Yes, indeed, but these pictures are still on view in many classrooms today. Progress has, of course, been made in the recent decades toward objectives and methods of teaching which give proper place to ideas, to meanings, and to relationships; but even now rote learning, parrot-like reciting, and excessive verbalism are not uncommon. Evidence of this condition abounds. Witness the ever-expanding collections of "boners" and

"howlers" which have been assembled from every subject and from every grade, such as the following:

"The circulatory system is composed of veins, arteries, and *artilleries.*"

"Socrates died from an overdose of *wedlock.*"

"Pompeii was destroyed by an eruption of *saliva* from the *Vatican.*"

Reasons for the Excessive Emphasis upon Verbalism

There were, of course, reasons for the rather general acceptance of glib verbalism and mechanical skills in the place of meaningful learning. All these reasons obtain today in some measure; and some of them, as a matter of fact, have been accentuated. On this account it is worth while to examine them briefly. Some of the reasons were, and are:

1. The prevailing psychology of learning, with its emphasis upon isolated units or items rather than upon wholes and relationships.
2. The rather general dependence upon textbooks which frequently are little more than compendia of detailed facts and of generalized summaries.
3. Overconfidence in teaching by telling, and in learning by memorizing what has been heard or read.
4. The rapidly expanding content of the curriculum, which encouraged teachers to attempt the impossible.
5. The poor quality of teacher-preparation and the limited experiential backgrounds of teachers.
6. The wasteful practice of individual recitations as contrasted with cooperative group activity.
7. The tendency to make of schooling an artificial thing by divorcing it from the activities of ordinary life.

1. According to the psychology dominant during the recent past, teaching consisted in calling pupils' attention to significant facts and skills and then in seeing that they "mastered" them. Among the procedures commonly employed to get pupils to attend to the selected items were such instructions as the following: "As you study the next chapter, be sure to learn the important points listed on page 146"; "For the next time be able to recite the names of the first ten Presidents"; "Be able to bound the state of Nebraska and to tell its principal cities and its main products"; "Learn how to do long division as shown on page 79"; "Be ready tomorrow to tell me the date and place of Wordsworth's birth, together with his chief poems and the reasons why he is regarded as a great poet." The recitation period was essentially a "testing" period and gave the teacher opportunity to ask

specific questions which could be answered with a word, to have pupils work set examples, and otherwise to have them demonstrate that they had mastered the particular tasks he had set them. ("Go to the blackboard and draw the figure for today's proposition"; and the textbook figure regularly appeared and was accepted.) And all this seemed to be consistent with (if indeed it was not required by) the best in current psychological theory with respect to learning. Under these conditions there is little wonder that verbalism prevailed.

2. The practice of making textbooks the chief or exclusive source of instructional material fits nicely into the oversimplified theory of learning just described. Teachers quite generally assumed that texts contained all that needed to be learned. But, typically, textbooks are condensed accounts or descriptions, consisting of conclusions, summaries, and generalizations. The latter are of service primarily because they are short expressions of relationships which are dependent upon many intelligible facts, conditions, and the like. If these last are not understood, conclusions and generalizations are necessarily deficient in meaning. For this reason textbooks cannot by themselves provide a sound and adequate basis for understanding.

3. Traditional methods of instruction tended to give children faulty notions respecting the ultimate authority of textbooks and teachers. Things were so because they appeared in texts, or were said by teachers. When they supplemented the textbook with other material, teachers told their pupils what to learn, but seldom why they should learn it or why they should believe it. While it is, of course, impossible for children to reason out all the relationships they must know, there is in this fact no justification for disregarding all opportunities for them to do so. Failure to encourage this kind of activity on their part is tantamount again to fostering verbalism and rote learning without understanding.

4. That the content of the curriculum has expanded rapidly is beyond question. And the end is not in sight. The world is becoming steadily more quantitative, with new demands upon arithmetic and upon mathematics as a whole. The borders of our scientific knowledge have been extended in a corresponding manner; and there are growing demands that the history, geography, and cultures of the Far East, Africa, and South America receive far more attention than they have received in the past. The expansion of the curriculum has posed a difficult question for teachers and for the school in general—whether to try to "cover the ground," tremendous as it is, or to select and to teach the selected content well. Unfortunately, the choice seems to

have been made more commonly in favor of the first procedure. A comprehensive coverage almost inevitably leads to the learning of a sampling of facts and little else. Still, it is more economical of time and is pleasanter, even if self-delusive, to assume that the ability to give back words is evidence of understanding.

5. The fifth reason mentioned above for overemphasis on verbalism at the expense of understanding is the poor quality of teacher preparation and deficiencies in their experiential backgrounds. To teach the modern curriculum well one must know far more than the subject matter learned in childhood and in youth, and one must have had experiences with many things other than books, valuable as they are. It is short-sighted policy to think of teacher-preparation too much in terms of courses in education and in the subject fields, the latter being restricted to the content for which each teacher will be responsible. And it is short-sighted policy, also, to think that young people who have lived all their lives in the public schools of their communities and in the single colleges of their choice know very much about the world or about life in that world. It is too much to suppose that teachers with such inadequate backgrounds will themselves appreciate fully the meaning and the significance of what they teach, at the same time recognizing its limitations. To believe these things and to plan teacher-preparation accordingly is to fasten still more closely the grip of verbalism and formalism upon the school.

6. The class recitation is not often economical of time or conducive to the development of understanding. One child talks while the others listen. Moreover, in the effort to bring into the recitation as many children as possible, the teacher tends to ask many short fact-questions and to set other tasks which are satisfied by routine, relatively mechanical responses. As has been suggested above, telling is not teaching; nor does listening and watching tend to promote thorough, meaningful learning. A valuable substitute—one which assures more general and more active participation, and hence, in all probability, more meaningful learning—is the co-operative group project or problem. In such circumstances, purely rote and mechanical performances are likely to be shown up precisely for what they are.

7. Last of all, verbalism has been encouraged by the separation of schooling from the ordinary activities of life. Some, unfortunately, have done too good a job of selling the public the notion that education is one thing and life quite another thing. As a consequence, parents have come to prize unduly a sterile type of learning. An anecdote, admittedly extreme, will serve to illustrate the awe with

which many parents regard knowledge which they themselves do not have or understand. A mother was entertaining the Ladies' Aid when her son came bounding up the steps and through the front door. The proud lady remarked, "That's Henry. Henry's in high school this year. He's studying foreign languages. Henry! come here and speak some algebra for the folks."

Advantages of Learning with Understanding

The two immediately preceding sections of this chapter have been largely negative. Their purpose was to show that both in the past and in the present, though to a less extent, understandings have not been given adequate prominence as learning outcomes; and they have disclosed some of the chief reasons for this comparative neglect. It is time now to turn to positive considerations and to see why understandings are important in teaching and in learning.

Meaningful Learning Is Economical Learning. For this statement there is ample support in both psychological and educational research on learning. To establish its truth in a less formal manner, it is suggested that the reader write out and attempt to memorize a series of fifteen nonsense syllables (e.g., gup, laj, ped, etc.) or a passage in a foreign language which he cannot translate. He will discover, or rediscover, that what he does not understand he must learn laboriously. On the other hand, by appropriate procedures he can demonstrate to himself that what he does understand he learns easily. Compare in terms of time, effort, and happiness the attempts of two children to learn a passage from Bryant's "Thanatopsis." Let one of the children be taught or otherwise grasp the meanings involved; let the other have only a vague understanding of the words and phrases he memorizes. The contrast should give convincing evidence of the contribution which understanding makes to learning.

There are learning tasks in which the element of understanding, being necessarily very slight, can make for but little economy in learning. (These tasks, for the most part, involve the establishment of arbitrary associations, as in learning that this object is called "horse," that one "box.") There are many other learning tasks in which understanding may *seem* to slow up rather than to facilitate learning. For example, any first-grade child after a few repetitions can say, "Two and three are five." To take time to build meaning into the expression may be thought wasteful. This view comes from oversimplification of the learning task and of the desired outcomes. In this case—and in the many other similar cases in which this over-

simplification may occur—we need to recognize that learning involves more than the acquisition of the ability to repeat a verbal formula. The combination $2 + 3 = 5$ will be used in countless ways; it can be so used only if it is understood; hence, in the end, time spent in engendering meaning is time well spent.

Learning with Understanding Is Relatively Permanent. Meaningful learning is, then, more economical of time and effort than is senseless learning. But it has other values as well. One of them is that meaningful learning is retained longer and more accurately. Again there is plenty of research, psychological and educational, to confirm this statement. The reader may, however, verify the truth of the statement from his own experience. One has only to recall one's difficulty in repeating a list of nonsense syllables, the names of persons met casually at a social function, or an ill-understood poem one week after committing it to memory. On the other hand, one can generally bring to mind with comparative ease after the lapse of a week material that was meaningful and of continuing value at the time of learning. The implication for teaching is obvious: whatever we would have children remember, we must help them to understand; and the longer the desired retention, the more essential is understanding.

The Effects of Learning with Understanding Are Cumulative. This statement means that understanding facilitates the learning not only of the immediate task but of subsequent tasks as well. Its effects may extend far in time. This fact is well illustrated in the case of the social studies. If basic concepts are given meaning on their first occurrence, the sense of the reading matter then being studied is naturally apprehended so much the better; but so is the sense of reading matter containing these concepts which is encountered at a later date. The cumulative effects of understanding are also well illustrated in the case of mathematics. We have long known that, in such logically organized subject matter, foundations are of critical importance. With a solid background of meanings sound progress is at least possible; without it, learning must continue to be blind, superficial, and comparatively useless. Diagnosis of learning shortages very commonly reveals the real cause in some but vaguely understood process or principle which had been "taught" years before.

Learning with understanding has (or may have) the effect of establishing in children the habit of *expecting* to understand. Having this habit, children insist upon mastering each new task in a meaningful manner. Several groups of children who had learned arithmetic as a meaningful system for two and a half years were suddenly,

and deliberately, taught a new process without explanation. They were told what to do and shown how to do it; that was all. These children made the lives of their teachers miserable when they (the teachers) for experimental reasons refused an explanation. And many of the children, denied help from this quarter, sought it in other places or discovered the relevant reasons by their own efforts. Few long-time learning outcomes are as valuable as is the habit of expecting to understand.

Understanding Results in Learning with Functional Value. Nothing, whether idea or skill, which is acquired in school is ever *used* in precisely the way in which it was learned. There are always differences, no matter how minor, between the learning situation and the situation of use. If the gap is bridged at all, it is bridged by the discovery of relationships. We deal here with the psychological phenomena of transfer.

It is characteristic of that learning which is devoid of understanding to be inert, not susceptible to transfer and application. The child may be able to make correct statements using the terms "tons," "legislation," and "acid" without at all understanding their nature. He may not know what they are, how they behave, what their uses are. Such a child is scarcely apt to make intelligent use of these terms in solving life problems, or for that matter in understanding and assimilating information involving these terms. Their knowledge is, in a word, functionless. It is like the "learning" mentioned by Quick in his *Educational Reformers:*

> In an elementary school when the children "took up" geography for the inspector, I once put some questions about St. Paul at Rome. I asked in what country Rome was, but nobody seemed to have heard of such a place. "It's geography!" said I, and some twenty hands went up directly. Their owners answered quite readily, "In Italy."

On the other hand, it is characteristic of learning with understanding to be functional, transferable. The broader the meaning of an idea, the greater the understanding of a skill, the larger is the probability of its usefulness outside the classroom. There is nothing mysterious or magical about this business. Think, if you will, of an idea (or skill) as having tentacles. Then the richer its meaning, the more tentacles it has. And the larger the number of tentacles, the more objects it can reach and hold.

The modern conception is that education is the acceleration and the direction of the growth of each individual. According to this conception, the curriculum is no more than the provision of educative

experiences appropriate to this end. It includes anything which will enable the child as a child and later as an adult to act, feel, and think as we believe he should act, feel, and think. The school is no longer concerned with closed systems and compartments of learning; it is concerned with ideas, attitudes, and skills which influence actual living both now and in the future. On this account it is but natural that increasing attention be given to learning which is accompanied with understanding. Such learning functions.

Measuring Understanding

Comparative Neglect of Understandings in Current Evaluation Practice

It needs to be said again that there is a proper, a necessary, place in evaluation for the measurement of factual knowledge and of skills. It happens that this yearbook deals with a different problem, namely, the measurement of understanding. Hence, when it is said, as in the caption above, that understandings are neglected in current evaluation practice, there is no implication that the evaluation of facts and skills must be abandoned. The import of the statement is, rather, that meaningful outcomes of learning need to be measured more carefully and more extensively than is now the case.

With this explanation out of the way, let us consider the evidence that understandings are not evaluated as they should be. For obvious reasons it is impossible here to assemble what would amount to *proof* of the statement. Instead, it must suffice to examine samples of tests on the assumption that they are typical of current practice. The reader must satisfy himself as to the validity of this assumption. On this point there is no doubt in the minds of the writers. Let us begin with four samples of tests or parts of tests which were prepared by classroom teachers.

Sample 1. Classroom test in second-grade reading.—To determine the status of her pupils in reading, a second-grade teacher used the written test below. It is the whole of her test.

The reading selection: Father was going to the store.
Jane was going to school.
Father walked.
Jane rode on a bicycle.
Mother waved to Jane.

The questions:
1. Who rode on a bicycle? ......
2. Who waved to Jane? ......
3. Who walked? ......
4. Where was father going? ......

Note that in making these test items the teacher merely substituted the question words "Who?" or "Where?" for the nouns in the sentences read. Therefore, in answering the questions, the child had only to find the statements which contained the last words. Little reflective thought was required, and indeed correct answers for the questions might have been found with but the slightest amount of understanding of the reading selection.

By contrast, the following questions, or others like them which might have been used, measure higher levels of understanding:

1. Was Jane going to the store? ......
2. Did mother go with Jane? ......
3. Was father going to school? ......
4. Did mother wave to Jane? ......

Sample 2. A complete classroom test in fourth-grade science.—After several days of study of a unit on magnets, the teacher gave the following test:

1. What color is the north pole of a compass needle?
2. Is the compass needle a magnet?
3. What shape are magnets?
4. Will a magnet pick up sticks?
5. Will a magnet pick up paper clips?
6. Where is the Magnetic Pole?

The study of the unit had included activities which provided every child with the specific information he needed to answer the questions. Here is no measurement of understanding, or at least there is measurement of only the lowest levels of understanding. Higher levels could have been tested by the use of such questions as:

1. What is a good reason for coloring the north pole of a compass needle?
2. How can you show that a compass needle is a magnet?

Sample 3. Part of a classroom test in ninth-grade history.—Directions: Match the numbered items in the first column with the correct lettered items in the second column.

1. Birthplace of Napoleon	a. Belgium to France
2. Treaty of Campo-Formia	b. Marengo
3. The treaty of peace with the church	c. Corsica
4. The Cisalpine Republic	d. Milan
5. The second invasion of Italy	e. Naples
6. Parthenopean Republic	f. The Concordat

The rest of the test, not reproduced here, was similar in character;

it called for the supplying of pat answers; the items of the test had been learned almost as paired associates from the history text.

Sample 4. Part of a classroom test in economic geography.—At the conclusion of a unit on wheat, the teacher used a true-false test as her sole means of evaluation. Some of the questions, typical of the rest, follow:

1. Wheat was first grown in Egypt.
2. In the Bible the word "corn" means "wheat" most of the time.
3. The center of wheat production in the U. S. crossed the Mississippi River in 1880.
4. Russia leads the world in the production of wheat.
5. Ontario is the leading wheat province in Canada.
6. The simplest of wheat milling devices is the mortar and pestle.

The criticism to be offered of the four classroom tests above is not that they are worthless. On the contrary, the items in general seem to call for important facts, and they are constructed adequately. The trouble is that, however well they measure factual knowledge, they measure little if anything else; and yet these teachers were content to limit evaluation to this one kind of learning outcome. The fallacious assumption implicit in their practice is that they had measured all that needed to be measured.

At this point, a digression may be permitted. The objective test has not proved to be an unmixed blessing in the hands of many teachers. Convinced by apparently authoritative statements that the essay test is unreliable and consequently valueless and that the weaknesses of such tests can be avoided by using objective tests, teachers in increasing numbers adopted one or more of the new-type test forms. They soon discovered great difficulty in framing "thought questions" in the pattern of these test forms. On the other hand, they found the new forms admirably adapted to the testing of factual knowledge. The result of it all has been that too frequently objective testing has become exclusively fact-testing. This trend is unfortunate, and it is unnecessary. The new types of test items *can* be utilized to measure meaningful outcomes, and they should be so used. One of the major aims of this yearbook, especially of Section II, is to show the possibilities of objective testing in this connection and to encourage its wider use for this purpose.

Procedures other than paper-and-pencil testing are, of course, employed in the classroom to evaluate learning. Among them is the practice of questioning pupils orally. If these other procedures but served to measure learning outcomes in the form of understandings, the de-

ficiencies of classroom tests would not be too serious. But such does not seem often to be the case. Far more common than questions and exercises which call for meaningful reactions are those which, as mentioned earlier in this chapter, can be satisfied with memorized statements and mechanical skills. The same criticism applies many times to a wide range of "work products" by which we undertake to judge learning. The "composition" is likely to be evaluated in terms of its mechanical excellence rather than as evidence of understandings gained through experience. And the "bird house" may be appraised purely as a well constructed or poorly constructed job, although the teacher may have had in mind certain understandings as desired outcomes.

To come now to standardized tests: How well do these instruments evaluate understanding? Space permits but two exhibits which, however, can safely be said to be typical of most standardized tests.

Sample 5. Part of a standardized geography test.—The following six items appear consecutively in the geography section of a widely used test battery:

1. Raisins are dried (1) plums (2) cherries (3) grapes (4) blackberries (5) loganberries.
2. The smallest of the continents is (1) North America (2) South America (3) Europe (4) Africa (5) Australia.
3. The natives of Central Africa value elephants chiefly for their (1) ivory tusks (2) milk (3) meat (4) work in farming (5) strength in helping to fight off attacks.
4. The ocean that is around the North Pole is called the (1) Atlantic (2) Arctic (3) Pacific (4) Antarctic (5) Indian.
5. The body of water that lies between North America and Europe is the (1) Indian Ocean (2) Arctic Ocean (3) Atlantic Ocean (4) Pacific Ocean (5) Antarctic Ocean.
6. The most important fruit that we get from the Hawaiian Islands is (1) grapefruit (2) pineapples (3) oranges (4) lemons (5) bananas.

Sample 6. Part of a standardized test in science.—Following are five consecutive items from the science section of another well-known test battery:

1. The heart pumps (1) water (2) air (3) blood.
2. A bird that builds its nest on the ground is the (1) meadow lark (2) blue jay (3) oriole.
3. Nicotine is (1) a drink (2) drug (3) food.
4. Reading lights generally should be placed (1) at the rear (2) in front (3) below.
5. If you suspect a gas tank leak (1) look for it with a match (2) do nothing (3) report it.

The material of neither Sample 5 nor Sample 6 has been chosen to discredit the standardized test in question; other parts of the same test batteries or items from many other available tests could have been selected with the same results, for they also would have demonstrated the tendency of such tests to measure unrelatd facts and to neglect more meaningful learning outcomes. If we could be sure that the possession of facts is a guarantee of equal facility in their use, the neglect of understanding could be overlooked. We have no such assurance, however, for research has found the relationship between the two to be slight.

To conclude: Tests made by teachers, other forms of classroom evaluation, and standardized tests are alike in giving little attention to understandings. This evil condition needs to be corrected, for the effects on teaching, on learning, and on research are unfortunate.

The Effect of Measurement upon Instructional Procedures

It is a common practice of the supervisory or administrative staff of a school system to collect evidence on pupil achievement. The effects of this practice may be more far-reaching than is anticipated. If the tests used measure the learning outcomes which a teacher has been trying to achieve with his pupils, then he is encouraged to continue and even to intensify his efforts in that direction. But the tests may measure outcomes which the teacher has not endeavored to stress. In such cases almost anything may happen.

Consider the following instance. As part of the midyear survey of achievement a reading test was given to a certain sixth-grade class. This test contained many items such as: (1) Which conclusion based on the facts in the article is sound? (2) What is a good title for this selection? (3) What is the main idea of paragraph 2? (4) For what paragraph could "Deposits of Bentonite" be a heading? (5) What is the author's purpose in paragraph 1? (6) In preparing an outline of paragraph 4, what main points should be included?

Throughout the next semester this teacher placed major emphasis upon getting the main thought of paragraphs, upon drawing conclusions from material read, upon discovering relationships between paragraphs, and upon selecting the main points of paragraphs, the last as a step in outlining. The influence of the measurement program upon instructional procedures in that class is clearly observable. In this case, the effects may be called beneficial, for the teacher was driven to teach reading skills which he had previously neglected, in

spite of their obvious values for pupil achievement in science, geography, history, and other content subjects.

The effects, however, can just as possibly be detrimental. Two cases of this kind should be mentioned. The one occurs when the measurement program confirms teachers in injudicious or in inadequate instructional procedures. If, for example, the teacher stresses factual knowledge in his instruction and the tests used measure only this learning outcome, damage has been done. Factual knowledge will continue to be stressed, and meanings and relationships will continue to be neglected. Nothing else should be expected. The teacher whose pupils satisfy the criteria of learning which are approved by the administrative staff has no reason to change his instructional procedures or the goals which he seeks to attain; quite the contrary.

A second case in which the influence of the administrative measurement program may be harmful occurs when the teacher is discouraged from emphasizing proper learning outcomes and from employing instructional techniques which are adapted to this end. Imagine the chagrin of both students and teacher in an American history class in which understandings have been consistently developed, when, at the end of the term, the quality of achievement is evaluated by some school official purely in terms of students' ability to answer simple factual questions. That this teacher will put emphasis upon understandings in his next history class is scarcely a reasonable inference.

Rather, in all probability, this teacher will adopt factual knowledge as his objective in instruction. Regrettable as this may be, it is certainly understandable. By stressing facts, the teacher knows that he will give his pupils the preparation they need to succeed on the tests they will have to take. By so doing, too, the teacher protects himself, especially when, as is sometimes true, he knows that he will be rated according to the relative achievement of his pupils on factual tests. No small part of the blame for exaggerated concern about the learning of facts and mechanical skills is chargeable to the practice of administrative officials in stressing verbalism to the disadvantage of meaningful learning in their testing programs.

The implication of the foregoing paragraphs is clear: The measurement program planned and executed by the administrative staff has direct effects upon instructional practices. These effects may be beneficial, or they may be harmful. Obviously, they should be beneficial. They may be made so if the administrative staff is careful to evaluate not only factual knowledge (which is important in its own right) but also understandings and meaningful learning in general.

The Effect of Measurement upon Learning Procedures

Children soon discover the wisdom of learning what they will be tested on. For this reason the kind of evaluation employed affects children's learning procedures and determines their actual learning objectives, regardless of the objectives that may have been set in theory. Few intelligent children continue long to tease out relationships and to understand principles and processes when their learning is evaluated according to other criteria. And we accomplish nothing at all by exhorting children to understand what they learn if we do not measure their understanding.

Tests and the activities called for by other evaluation devices give children their most tangible cues to the goals they are to achieve. It follows, therefore, as certainly as night follows day that evaluation must be designed so that children may identify the right goals for their learning. If understandings are our goals, at least in part, our practices of evaluation must include means of measuring such outcomes. If they do, children will quickly enough adapt their learning procedures to meet this demand.

Effect upon Research

The inadequate representation of understandings in standardized and other tests has affected educational research adversely. The worth of experimental programs is almost invariably appraised in terms of test data. Quite frequently a standardized achievement test of the type illustrated above is the most important, if not the only, instrument used to measure outcomes. Even in investigations where the experimenter makes his own tests, the practice of measuring only unrelated facts and formal skills seems to be prevalent. Data obtained from such tests may not show significant differences between experimental and conventional procedures even when such differences actually exist; and, conversely, they may show differences which are not educationally significant when other outcomes are taken into account. As a consequence, in many experiments evaluation has been incomplete or inappropriate. There is, of course, no implication that this condition, however common, is inevitable. It *is* possible to devise instruments and procedures to assess meaningful learning outcomes and to use them in experimental inquiries. Indeed, precisely this improvement is to be increasingly noted in the more careful investigations of the past decade. Nevertheless, it remains a fact that the development of means to judge understanding more adequately will for a long time continue to be an important aspect of educational research.

Importance of Knowing Initial Status with Respect to Understanding

For many years we have believed that good teaching begins where the child is, at the point to which his achievement has brought him. We realize that we must take into consideration what a pupil already knows if we are to guide his learning from then on in an effective manner. A fifth-grade teacher, in trying to teach the use of guide words in the dictionary, discovered that several members of her class did not know alphabetical order. Not only would it have been difficult in these circumstances for the children to learn much about the use of guide words, but their learning, in view of their lack of a basic understanding, would have been quite useless to them.

The principle of good teaching cited above is of general application. Certainly it holds with special force in the case of learning which involves understanding. For meaningful learning it is essential that the child have the proper background. Knowledge of children's status at the outset of any new unit of learning protects the teacher from both of two errors in instruction: teaching "over their heads," on the false assumption that they have already attained the requisite level of understanding; and wasteful and boring reteaching, on the equally false assumption that they lack understanding which they actually possess.

Importance of Knowing Status of Understanding at Later Stages

The implications of the principle, "Begin where the child is," do not stop with initial instruction. As part of his job the teacher must continually check to make sure that he is "losing" none of his pupils, that all of them are extending their understanding as learning progresses. This day-by-day checking and probing is a form of measurement; it is also an integral part of teaching. Fortunately, the procedures for this continuous checking of understanding are already in use among good teachers.

A child in reporting on irrigated farming in the Rio Grande Valley made the statement: "It's a great place for growing alfalfa. They get two tons per acre." The teacher then asked how this yield of two tons per acre compared with the local yield. (In asking this question, be it observed, she was requiring the child to relate his statement about an unfamiliar section of the country to conditions in his own section.) The child could not answer the question because he did not know the average local yield. After some discussion, the class decided to postpone further consideration of the statement until

they could investigate. The next day local yields of two, two and a half, and three tons were reported. The conclusion was reached that the irrigated country of the Rio Grande was not an especially good place for growing alfalfa.

The teacher, realizing that the child who made the report had not stated all the facts, asked: "Then, why did the reading material that Bill consulted say that that was good alfalfa country?" Careful rereading of the article disclosed that *four* cuttings were made per year along the Rio Grande. The class then realized that they had to compare the local yield of perhaps three tons per year per acre with an annual yield of eight tons per acre and agreed that the Rio Grande Valley was after all an excellent region for alfalfa.

Schoolroom procedures like that just described are not uncommon. They might well be commoner. The best means of combatting inefficient, erroneous, meaningless, and incomplete learning is to obtain daily evidence. And the process of obtaining this evidence, of understanding as well as of other aspects of learning, is measurement. The wise and artistic teacher will make the most of every opportunity to maintain a constant watch, by whatever means, over the continuous development of understanding.

Summary

The purpose of this chapter is to explain why understandings must be taught and must be measured. The reason which gives importance to these educational tasks is the fact that understandings are basic to rich and effective living. Yet, in spite of their demonstrable values, understandings have been neglected in the school—and they still are too often neglected—in favor of other learning outcomes, such as verbalism, barren factual information, and mechanical skills. In the foregoing discussion, attention is given to several factors which have produced this relative neglect, among them: an inadequate psychology of learning, over-reliance on textbooks, the tendency to teach by telling, the tremendous expansion of the curriculum, etc. This discussion is intended partly to account for failure to stress understandings adequately and partly to warn teachers against these continuing factors and so to check their influence.

It is also shown that understandings are not likely to be taught if they are not also evaluated. When administrative officers of a school devise testing programs without including meaningful types of learning outcomes, they encourage the teacher to disregard such outcomes, and in turn the teacher encourages his pupils to point their energies

in other directions. And when the teacher himself initiates measurement and excludes meaningful outcomes, the effects in terms of pupil behavior are the same. In the end, children tend to learn what they believe they are expected to learn. The implication of this fact is that in measurement, whether planned by the teacher, by an administrative superior, or by the two in conjunction, a prominent place must be accorded to understandings.

CHAPTER III

THE NATURE OF UNDERSTANDING

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When a geometry student sees the usefulness of the Pythagorean theorem for laying off the corners of a tennis court, we may be sure that he has some understanding of that theorem. When a fifth-grade pupil by means of his maps discovers for himself a probable connection between the physical features of a region and the manner of life of its inhabitants, we may be sure that he too has some understanding, in this case of the geographic principles involved. And when a primary-grade pupil translates the statement $5 + 2 = 7$ into a concrete representation, by setting up one group of five objects and another of two objects and then combining them into a new group of seven, we may be sure once again that he also has some understanding, this time of the abstract relationships in the statement.

A technically exact definition of "understand" or "understanding" is not easily found or formulated. No attempt will be made in this chapter to arrive at such a definition. Quite apart from the difficulty of the undertaking, it would seem to be unnecessary, for the terms are employed by most people, school people included, with considerable agreement as to meaning. For the purposes of this yearbook it will suffice to consider this practical concept of "understanding" in a critical but nontechnical manner. We shall begin with a broad statement (not a definition) about the nature of "understanding." We shall then both elaborate and limit this statement in a series of seven related propositions. By the time the reader has reached the end of the chapter, it is hoped he will have, not a precise definition of the

word, but rather a clear and useful conception of the essential characteristics of "understanding" as a psychological process and as an educational outcome.

General Concept and Essential Characteristics of Understanding

1. *As a start, we may say that a pupil understands when he is able to act, feel, or think intelligently with respect to a situation.*

Without explanation, this statement—what psychologists call an imperfect operational definition—would amount to little more than the substitution of several undefined words for the word which is to be defined. Two terms in the statement need to be considered further, namely, "intelligently" and "situation." Let us begin with the latter term.

"Situation" is used here to mean any set of circumstances which call for an adjustment. Several illustrative situations have already been mentioned. They serve to show that situations differ greatly in kind, and therefore in the demands which they make upon us. Some situations are primarily intellectual; some, primarily emotional; some, primarily mechanical; some, primarily social. The child who is assembling the parts of a puzzle faces a situation. So does the child who out of sheer curiosity wants to know more about something he has heard discussed; so does the child who is learning the names of new schoolmates; and so does the child who is studying a reading assignment. Situations, then, are infinite in their variety. Moreover, their variety does not stop with differences in kind, for within any given type of situation there are large differences in complexity, in urgency, in familiarity, and in the degree to which we are concerned with success in adjustment.

According to our preliminary definition, we react with *understanding* to such varied circumstances as have been suggested when we do so "intelligently." To make an intelligent adjustment to a situation, we must "know what it is all about;" we must see the immediate situation in terms of some larger whole; we must have some grasp on the relationships involved, be they social, intellectual, emotional, or mechanical.

These statements do not imply that we must always work out the essential relationships fully and logically and then utilize them as thoughtfully. Indeed we may not consciously identify as such the relationships we use or know that we are employing relationships at all, for that matter. As a matter of fact, many of our routine reactions are based upon understandings. When we put on a shoe be-

fore lacing it, it is because we understand the correct sequence of events. When we write a letter to a friend, without deliberate choice we use words which we understand and which we hope he will understand. When we behave properly in a social group, we are able to do so because we understand the conduct of others and know how to interpret its significance almost "without thinking." And when we casually check the coins given us in change after making a purchase, we are again employing understandings, even if unwittingly. In all such well-habituated reactions, then, understanding is to be found if we but look for it, and it is perfectly correct to speak of our behavior in these situations as intelligent. Neither "intelligent" nor "understanding" is appropriate, however, when by accident we hit upon some form of successful adjustment quite without knowing what we have done or why it is effective.

In the foregoing discussion it has been pointed out (*a*) that all behavior, all adjustment of whatever kind, starts with a situation. This situation creates on our part a feeling of need, or, to be technical, it establishes what the psychologist calls a state of disequilibrium. At times the feeling of need may be highly crucial, and it may lead us to formulate and to seek a definite goal. At other times, by contrast, it may be but dimly identified and recognized for what it is. But in any case something must be done about it; an adjustment is called for. Now, under what conditions may we behave intelligently?

The next point to be made is (*b*) that we can adjust intelligently to a situation to the extent that we have had the essential relevant experience. There is nothing magical about intelligent adjustment. It does not appear suddenly and inexplicably out of the nowhere. Instead, it is made possible by previous learning. The geography pupil referred to in the opening paragraph of this chapter is able to discover a relationship between the physical features of a region and the mode of life in that region because his earlier experiences have equipped him with the required knowledge and skills and with an eagerness for more knowledge. The small child laces his shoe after putting it on rather than before because through experience he has learned this to be the correct order of activities. In the absence of such experience, he would be as likely as not to do the lacing first. To repeat, adjustment can be intelligent only when the doer has had relevant experience. The effect of relevant experience is to produce in the learner changes which he can carry over to new situations. As will be made amply clear later in this chapter (point 6), sheer amount of experience is by itself no guarantee of intelligent adjustment.

Suppose now (*a*) that the pupil faces a situation, and so has a need or purpose, and (*b*) that he had the necessary relevant experience. Can he be expected to behave intelligently? Not necessarily, for several other conditions must be met: (*c*) he must be able to identify the critical aspects of the situation; (*d*) he must find appropriate ways to attack these critical aspects; (*e*) he must want to satisfy the need presented to him by the situation; and (*f*) all other factors in the situation must be favorable. If any of these conditions is not satisfied, his adjustment may not be intelligent.

Many a pupil possessed of the requisite relevant experience nevertheless fails in intelligent adjustment because he is unable to analyze the situation confronting him and to pick out the element or the elements which call for special attention. This difficulty does not, of course, arise in the case of completely familiar situations. By definition such situations contain no obscure or hidden features; on the contrary, they are all understood, and accordingly the ensuing behavior may be intelligent in the fullest sense of that word. But to the degree that situations are new and complex, to the degree that they present problem situations, this difficulty does appear. The geography pupil, for example, may not be able to isolate the aspects of his problem to which he should attend, and so may not be able to use his knowledge to establish the relationship in which he is interested. He just does not know "where to work." The geometry student may see no resemblance between the tennis court and the abstract textbook figures by means of which the Pythagorean theorem was developed. In such instances the function of the teacher is clear. He must not only assist the learner to identify the critical features of his particular problem, but he must help him to develop habits of analysis which will be useful in similar problem situations. This teacher responsibility is discussed at greater length further on in this chapter (point 7).

Having located the significant aspects of the situation, the pupil must next find a way to deal with them. Again, when the situation is simple and familiar, the pupil is in no difficulty at this point; he possesses, and he knows he possesses, the needed forms of reaction. He has only to make use of them, and he is apt to do so successfully in a routine fashion. In problem situations, on the other hand, his search for appropriate reactions is not so easy. At times he may actually have the needed facts and skills somewhere in his behavior repertoire. If so, this step is for him one of selection. At other times he may not be so fortunate, and he must combine and integrate facts and skills into what is really a new reaction. Thus, the process of

finding ways to meet a need takes either of two forms: the selection of a reaction which one has already learned, or the evolving of a new form of attack.

The existence of a situation calling for adjustment, with the resultant feeling of need, the possession of the necessary relevant experience, the discovery of the critical aspects of the situation, and the finding of appropriate methods of attack—all these assure only readiness to behave intelligently. The reader will note that we have said the pupil understands when he *is able to act intelligently*. Whether that kind of behavior ensues may involve other factors. The pupil may not want to behave intelligently, or obstacles of one kind or another may prevent his doing so. Time limitations, for example, may interfere; there may be emotional blockings; a new need may supercede the one which first stimulated activity. For example, the child, knowing better, may lace his shoe before putting it on just to see what will happen. The geometry student may not like his teacher; or, the bell may ring, meaning that he must go to work on some other subject. The geography pupil may be afraid to risk criticism in case of failure, or may not want to appear "too smart" among his schoolmates. In all these cases the actor may have been able to react intelligently; but he did not. This fact carries the implication that absence of intelligent behavior does not necessarily signify lack of understanding.

2. *Rather than being all-or-none affairs, understandings vary in degree of definiteness and completeness.*

The foregoing statement is not in accord with the commonly expressed notion that either we understand or we do not understand. A moment's consideration will verify the falsity of this latter notion and the truth of the italicized statement. We may not know much about the "stratosphere"—certainly much less than does the aviator who takes his plane to heights of 25,000 and 30,000 feet; but we are not wholly without understanding. Our understanding is, rather, incomplete and lacking in detail. On the other hand, our understandings of "school" and "mother" are remarkably rich and full. Again, we are not without some understanding of 250,000,000,000; but our understanding of this number is vague and indefinite as compared with our understanding of, say, 10, or 36, or 85. In general, the completeness and definiteness of our understandings vary directly with the amounts and kinds of experiences we have had.

In a given situation, the degrees, qualities, and kinds of understandings manifested by the several members of a group of children

will be quite unlike. This condition prevails even when their experiential backgrounds are closely comparable, for there are certain to be marked differences in their purposes. Three third-grade children may have to solve the problem: "How much must I pay for three 19¢ booklets?" Pupil A's purpose is limited to securing the correct answer. In the problem he recognizes a cue which means to multiply; he multiplies, and he satisfies his purpose. His understanding of the mathematics involved is very low indeed, but it is commensurate with his purpose. Pupil B's purpose is also to get the correct answer, but he is interested as well in the mathematics of the computation. He multiplies 19¢ by 3 and secures 57¢, but he does not stop here. Further study shows him that this answer is 3¢ less than 60¢, a product he might have obtained by multiplying 20¢ by 3; and so, he discovers a short cut for mental multiplication which he may use at other times. Pupil C has still another purpose in finding the answer for 3 x 19¢: he wants to know whether he has enough money to buy three such booklets. While his activity in solving the problem may yield him little of Pupil B's mathematical insight, nevertheless he adds a bit to his understanding of the economics of buying and selling.

As a matter of strict fact, all learning produces some understanding. The memorization of a list of nonsense syllables, however worthless the accomplishment, still gives the learner a new and appropriate way of reacting (and so, some amount of understanding). He can, for example, respond correctly to the direction, "Repeat the syllables you have just studied." Since understanding in some measure accompanies all learning, the problem of education cannot be defined as the creation of understanding. As has been stated, some degree of understanding is inevitable if a child learns at all. The problem of education, rather, is to make sure that children possess the kinds and degrees of understanding which are essential to intelligent behavior consistent with their needs.

3. *The completeness of understanding to be sought varies from situation to situation and varies in any learning situation with a number of factors.*

The second italicized statement suggests that understandings occupy different points on scales of completeness and definiteness. Some ("stratosphere") lie well to the bottom near the 0-point; others ("mother," "school") lie well toward the top in richness and exactness. Still others lie at intermediate points. The third statement makes use of this conception and stresses the fact that in any given instance

of learning the understandings developed will and should differ in the positions they occupy on these scales.

To understand anything in its completeness, we should have a thorough grasp of its function, structure, and incidence. The adult in our culture has rather complete understandings of such things as hammers, knives, hoes, and the like, although actually he may know little of some of their relations, for instance, their origin and history. Likewise, the adult in our culture has rather complete understandings of such social agents as the policeman, the teacher, and the bricklayer, though close scrutiny would reveal large gaps in his knowledge even here. These samples of tools and social agents we understand pretty completely because we have had numerous and varied experiences with them, experiences related to differing purposes and extending over long periods of time. But it is obvious that, even were such complete understandings desirable, they could not be developed with respect to *all* aspects of our culture. Indeed, such understandings can be developed in connection with comparatively few items in our lives.

The time at our disposal to educate children in school is comparatively limited. This fact gives rise to the necessity, first, for selecting the understandings which are to be taught, and, second, for determining the degree to which these understandings are to be developed. Decisions at these points must be approached with care and made with great wisdom. Otherwise, we may be certain both of deficiencies and of waste in teaching and in learning. On the one hand, we shall squander valuable time in developing meanings which are not of the first order of importance. On the other hand, by attempting an impossibly ambitious coverage we shall fall short of developing essential understandings and of carrying these understandings to desirable levels of completeness and exactness.

This is not the place in which to catalogue all the criteria which should or may be used in selecting understandings for school instruction and in determining the degree to which they will be developed. Nevertheless, the nature of understanding will become clearer if we consider some of them.

a) How universal is the understanding; that is, how widely will it be needed? Clearly, some understandings are of more general usefulness than are others, and for first attention the more generally useful should be selected rather than the less generally useful. It is, for example, highly important (generally essential) that all school pupils understand the process of problem solving and the nature of de-

mocracy and of democratic living. It is not nearly so essential that all pupils understand the calculus; relatively few will have any need for this aspect of mathematics.

b) What are the chances that a given understanding will be fully learned or extended apart from direct instruction, in and out of school? If it is reasonable to expect the incidental experiences of life in the school and in the community to present enough opportunities and needs to develop an understanding to the desired level of completeness, there is little point in taking school time for this purpose.

c) How far are pupils capable of extending any given understanding? In some cases natural limitations of ability will restrict the extent to which understandings may be carried. In other cases limitations with similar effects are imposed by temporary deficiencies which will disappear with time.

d) How far must the understanding be developed to meet the present need? As has been stated before, it is practically never possible to develop complete meanings, and it is often advisable to stop the development even of an essential understanding at a rather low level of completeness, with the expectation that the development will be continued at later points in school.

e) On the other hand, what is the likelihood of future needs for an understanding? Just as criterion (*d*) would have us at times halt the development of understanding, so criterion (*e*) would have us at other times carry meaningful development beyond the demands of immediate needs. Criterion (*e*) therefore is a caution to provide insurance against future and perhaps unforeseeable demands.

4. *Typically, the pupil must develop worth-while understandings of the world in which we live as well as of the symbols associated with this world.*

To repeat, the number and variety of understandings which the successful learner must acquire are very great. For convenience in dealing with them we commonly undertake to classify them. The basis or bases of classification accepted at any given time vary with the purposes of the classifier. For our purpose here, which is to help the teacher comprehend the nature of understanding, we call attention to two general types of understandings: (*a*) understandings of the world in which we live, and (*b*) understandings of the symbols commonly associated with this world.

Many of the understandings which are sought through organized education are concerned with the world of things, animate and in-

animate, with the infinite relations which exist among these things, and with the operational procedures found in, between, and among them. In the sciences, for example, physical and biological, pure and applied, the number of such understandings looms large.

But the world in which we live is likewise a social one. Perhaps the most important understandings which the child must acquire involve people, their relations to one another and to him, and his relations to them. Psychologists tell us that such understandings are fundamental to the development of the child's personality, and social theorists rate them as essentials to successful group life. "Understanding others" as a goal in education has come to have a respectability equal to that long accorded Socrates' "Know thyself"; and such current educational phrases as the "community school," "Resource Use Education," "Inter-American Affairs" reflect a well-justified if often misplaced emphasis on the importance of social understanding. A functioning knowledge of social and moral issues has become a responsibility of the modern school. Esthetic values, too, have their social aspects. The "beautiful" varies with time and place and in terms of existing social understandings.

Associated with this world of people and things are a great variety of symbols, the understanding of which must of necessity be the concern of the school. Words, numbers, rules, principles, formulas, theories are all symbolic representations of things, procedures, and relations within the world. It is impossible to conceive of the learner behaving intelligently without acquiring an elaborate body of understandings of a symbolic nature.

Both experimental evidence and common sense justify the conclusion that the understanding of such symbols is necessary in order to understand the world of things, procedures, and relations. The possession of vocabulary, number facility, knowledge of rules and principles and formulas—these are all essential for successful adjustment to the problems of a complex life. Meaningful verbalization facilitates the acquisition of understandings, aids in their retention, and thus makes them available for later use. To accept the truth of this statement the reader has but to imagine the geography pupil or the geometry student faced with the needs described earlier but without words, formulas, rules, or other symbols necessary for dealing with them.

5. *Most understandings should be verbalized, but verbalizations may be relatively devoid of meaning.*

For the reasons stated, understandings should usually be verbal-

ized; that is to say, they should usually be reduced to corresponding sets of symbols such as words, numbers, or formulas. But this step of verbalization should come relatively late in the learning process, only after sufficient varied experiences to insure the development of the understanding in question. Otherwise, verbalization defeats its own ends.

Symbols acquired without being associated with the realities for which they stand are meaningless. As such they are quickly forgotten, or, if retained, they are limited in their usefulness to situations which are practically identical with those in which they are learned. Several instances of such empty verbalizations have been recorded in the second chapter of this yearbook. Perhaps one more is justified. It is found in the famous story, now a classic, as told by William James:

> A friend of mine, visiting a school, was asked to examine a young class in geography. Glancing at the book she said: "Suppose you should dig a hole in the ground, hundreds of feet deep, how should you find it at the bottom—warmer or colder than on top?" None of the class replying, the teacher said: "I am sure they know, but I think you don't ask the question quite rightly. Let me try." So, taking the book, she asked: "In what condition is the interior of the globe?" and received the immediate answer from half of the class at once: "The interior of the globe is in a condition of igneous fusion." [1]

6. *Understandings develop as the pupil engages in a variety of experiences rather than through doing the same thing over and over again.*

Further insight into the nature of understanding can, perhaps, be obtained through an examination into the conditions under which understandings do and do not develop. The educational *dictum* that "practice makes for improvement" does not always apply when it comes to acquiring understanding. In the case of skills, repetitive experiences may result in increased proficiency, and when this is the outcome sought, repetitive experiences should usually be prescribed. In acquiring a skill the pupil must initially give a rather high degree of attention to the process itself; consequently, changes in the learning situation may be distracting and harmful. But once a certain minimum of skill has been developed, repetitive experiences in and of themselves add little to meaning. To develop meaning the pupil needs a variety of experiences, and he must be able to concentrate on the

[1] William James, *Talks to Teachers on Psychology and to Students on Some of Life's Ideals*, p. 150. New York: Henry Holt & Co., 1899.

aspects of the differing situations which can contribute to a higher degree of understanding. To illustrate: The novice in cookery may be so confused by the complexity of pots and pans, measures and portions, stirring, mixing, and cooking, that freedom for attending to principles, generalizations, and implications is limited. In such a case, an essential minimum of repetitive experience is necessary, but, beyond this minimum, constant doing of the same thing may actually discourage further understanding.

The truth is, it is through varied experience that the child has occasion to analyze, synthesize, discriminate, compare, generalize—processes requisite to understanding. Experience in a variety of situations is basic to the growth of understanding. The child who meets a given formula in one type of situation only, even though he meets it often in this situation, does not generalize to the extent necessary to develop much understanding. The fact that a pupil in algebra must often be told the "type" of problem he is facing before he can solve it is not always the result of the child's ineptness or his poor foundation in arithmetic.

This aspect of the nature of understanding becomes especially important when we consider some of the highly complex, yet universally essential, understandings with which the school must be concerned. Take again as examples the process of problem solving (the scientific method) and the process of democratic living. These processes are exceedingly intricate. Yet, it is crucially important that all of us possess a considerable degree of understanding with respect to these processes. These facts together seem to warrant our setting these processes as major goals of education, goals for which all teachers, teachers of all subjects and of pupils of all ages, might well accept responsibility. It is absurd, for example, to imagine that one teacher in one or two courses can give children the training necessary for adequate understanding of and skill in problem solving—in identifying and isolating problems important enough for study, in assembling alternative hypotheses, in evaluating and testing out these suggested solutions. Such a task must engage the energies of teachers and pupils over a long period of years.

7. *Successful understanding comes in large part as a result of the methods employed by the teacher.*

There are obviously factors within the learner which limit the number of understandings he may acquire and the degree to which he may acquire them. We do not undertake to give the moron an

understanding of abstract mathematics or of formal grammar; the six-year-old is not expected to understand and appreciate the niceties of social relations; the child with experience restricted to urban areas will get only imperfect understanding of farming methods.

But within the limits set by the pupil's own capacity and make-up, the teaching-learning situation which is created for the pupil determines the character and the amount of understanding which he will acquire. An attempt to elaborate on this point might well develop into a treatise on good methods of teaching. Suffice it here to call attention to a number of elements in the teaching-learning situation which must be present if we are to expect understanding. Consideration of these elements will necessarily duplicate some of the discussion in the preceding chapter, but the points made need further emphasis, especially since they can contribute to the clarification of the nature of understanding.

a) Understanding depends largely on the degree to which the pupil is motivated initially by a recognized need. The relation of understanding to need was developed in an earlier section of this chapter, but it is again the subject of attention because it is exactly the point at which teachers so often fail. Whether or not any worth-while learning results from activity which is not purposeful to the child, that is, from activity which he does not recognize as meeting needs which he considers important, we will not dwell upon. Certain it is that only limited understanding comes from such activity. The emphasis on "doing something" found in many so-called activity schools does not necessarily result in learning that is more meaningful than that which occurs in the most highly formalized school programs. The child who builds a medieval castle at the insistence of his teacher and according to plans developed by the teacher gets little in the way of understanding. As a matter of fact, so far as understanding of life in medieval times is concerned, he might just about as well memorize a series of verbal statements in his textbook.

One further point concerning the relation between need and understanding should be made. Needs are of different sorts. Some of them grow out of meaningful and positive goals which pupils have; for example, the desire to build an airplane, to organize a club, to learn more and more about science, to prepare for medicine. Others are artificially injected into the child's life by parents and teachers and are often negative in character. Teachers may create needs through withholding approval, through denying privileges, through punishment; but the understanding which results from learning in response

to such needs is likely to be of a low order.

In any given learning situation the teacher's purposes usually comprehend and frequently go beyond those of his pupils. On occasion the teacher expects, but does not secure, intelligent behavior in response to "problems" which he sets for his pupils. The anticipated behavior may not occur for a number of reasons. One reason, the one with which we are here concerned, is that the situation as arranged by the teacher arouses no feeling of need for such behavior on the part of the pupils. It follows that, in so far as intelligent behavior and the use and development of understandings are involved, teacher-purposes and pupil-purposes must always be made to harmonize.

b) To develop understanding the pupil must possess a background of relevant experience sufficient for the needs of the moment. The person who would understand a particular situation must bring to bear on it learning acquired in related but somewhat dissimilar situations. No teacher would expect students who cannot add whole numbers to understand the addition of the more abstract symbols of algebra; but the need for relevant experience is not always so obvious. Social-studies teachers who carry their pupils into a complicated analysis of Chinese culture prior to adequate experience in and analysis of their own immediate environment cannot expect much understanding as an outcome. Failure to observe this principle may often be traced to a misconception of the term "relevant experience." A child whose experience has been limited to the nature of a thing may not be in a position to deal successfully with processes which involve this thing. A child who has seen automobiles, even ridden in them, may not be ready to deal intelligently with the principles inherent in their operation.

c) To acquire understanding the pupil must focus his attention on the aspects or details of the situation which hold the key to understanding. A child may have experience over a long period of time with some situation and still get little understanding of it. Even as adults, after long familiarity we may get new "insights" from attending to something in a new way.

Teachers have an important role to play in assisting children to direct their attention to the critical aspects of a situation. Much of the economy accruing from supervised study comes from help given at this point. Habits of critical analysis, of classification, of seeing relationships, of identifying those that are cause-and-effect in nature, of arriving at sound generalizations, all processes involved in understanding, are susceptible to development under wise guidance.

d) Understanding increases when a pupil formulates the results of his learning in his own words and in a variety of ways. One reason for the importance of self-evaluation in learning comes from the exercise it gives in identifying the desirable understandings which are implicit in an experience. Such formulations should, however, be in the nature of a rehearsal. Throughout any learning experience the teacher should encourage his pupils to verbalize, to talk about and write about the significant elements in the experience. And in so doing, it is well to keep in mind that exact reproduction of materials studied furnishes no additional understanding and offers no evidence of understanding. To accept such performances is but to condone rote learning.

e) To get understanding the pupil must make an active, aggressive approach to learning. Pupils must be encouraged to "discover" the things, processes, or relations of which understanding is sought. Most teachers talk too much. They are fearful of silence; they are unwilling to allow the learner the time necessary to muddle through. Oftentimes, too, our methods of presentation are such as to prevent personal discovery. Recognizing understanding of a certain principle in science as the desired outcome of instruction, for example, we too often start with it, define it, give our own illustrations, point out important ramifications, then (if there is time left) get a few additional illustrations out of the brighter members of the class. It is no accident that from such teaching the child often retains nothing more than the memory of a specific illustration.

f) Maximum understanding probably results when the teacher works in such a way that the pupil is allowed to participate actively and purposefully in planning what should be done at any given time, in the doing of it, and in evaluating success and failure. The teacher who dominates the learning situation to the extent of deciding exactly what will be done, and how and when it will be done, and who, himself alone, passes judgment on the success attained can expect little real understanding to take place. This is true whether he dominates through force or fear, or through the more subtle device of clever salesmanship. It is the nature of understanding that very little of it results when pupils work for fear of the teacher or for love of the teacher, for fear of low grades, or for desire for high grades.

Understanding of a particular kind is most complete when the learner himself has had opportunity to make a choice and has come to the conclusion that such and such is the important thing to do. Contrariwise, understanding is limited when some helper, whether it be the teacher or another pupil, does all the work for the learner.

The teacher who conceives of himself as a "walking encyclopedia" or as a "trouble-shooter," who does for pupils the things which they cannot or do not want to do, can rest assured that a minimum of understanding will result from his teaching. A complaint often heard from mathematics teachers that pupils can't understand problems until they are read to them might better be phrased: They *won't* understand problems as long as their problems are read to them. And why should they, if the teacher is ready and willing to do it for them?

And, finally, it is in the area of evaluation that many of us err most. Traditionally, it has been the teacher's job to evaluate. The child writes a letter, works a problem, performs an experiment, cooks a meal, translates a French story—and the teacher passes judgment on accomplishment. We who are teachers must come to see that successful understanding as well as maximum improvement comes from pupil participation at the point of evaluation.

8. *The kind and degree of the pupil's understanding is inferred from observing what he says and does with respect to his needs.*

We come now to the final point concerning the nature of understanding. It is only through observing the learner's behavior and through interpreting this behavior in terms of his purposes that we are able to judge concerning the amount and kind of understanding he has developed. Understanding is inferred from what the pupil says and does, and from what he does not say and do in situations confronting him. The teacher who would know the progress which he is making in developing understanding must be skilled in recognizing and interpreting such signs.

Some information concerning understandings, it is true, may be gleaned from observing the child in the learning situation and from inspecting the methods he uses in learning; but the ultimate test is his conscious use of his understanding in new but similar situations. When a pupil can use a word in places and in ways different from the context in which he learned it he may be said to understand it. Understanding of a principle means that one can identify its appropriateness and usefulness in situations where it has not been seen or used previously. Understanding of a process implies that one knows when and how to use it effectively.

Attention should be called to the fact that the school must seek a degree and kind of understanding which will lead to the use of learnings in the normal, out-of-school, life activities of the child. Evidence of this kind of understanding is not always easily secured in the

typical classroom situation. The teacher who has attempted to teach a principle in science may have to be satisfied with testing the extent to which the pupil can apply the principle in paper-and-pencil situations, but in doing so he should recognize the limitations of his procedure. The pupil's response in the test situation does not necessarily reflect the extent to which the principle will be used outside of the classroom. Still, care in constructing test situations will undoubtedly increase the degree of correspondence between the use of understandings in class and out. One purpose of chapter iv and of the several chapters in Section II of the yearbook is to show ways in which this end may be achieved.

One reason for the lack of correspondence between the use of learnings in the classroom and outside comes from a fact which was treated a few pages earlier in this chapter. The pupil's purposes in learning are factors in the degree and kind of understanding which he gets from a given experience. The pupil who acquires an understanding for the purpose of using it in teacher-made test situations gets one kind of understanding. The pupil who studies for the purpose of meeting some out-of-class need gets a different understanding. This is another way of saying that the teacher must be familiar with a pupil's purposes before he is in position to judge the nature of that pupil's understanding.

Given such knowledge of purpose, the degree of a pupil's understanding is reflected in his success in dealing with the understanding (*a*) in situations which are increasingly dissimilar from the one in which he presumably acquired it and (*b*) in situations which are more and more complex. The reader will remember from the earlier discussion that understandings are not all-or-none affairs. Too often, teachers are inclined to place a child in a single situation where success involves use of an understanding and then make judgments in terms of whether or not he uses it here. Such testing obviously implies that he either does or does not understand. Ideally, we should have a series of situations involving the understanding, the situations being graded in degree of dissimilarity from the original learning situation, and graded from simple to complex. Understanding would then be measured by the "distance" at which the pupil could successfully meet the situation, and by the "level" of complexity that he could react to successfully. Such a plan of testing would be laborious to develop and, perhaps, is not usually necessary. However, it is important that the teacher who is planning test situations do so with these two principles in mind.

SUMMARY

To meet the problems which inevitably face all of us, we must possess some degree of understanding. The success we enjoy in meeting these problems reflects, in part at least, the quality and extent of our understanding of these problems. For this reason understanding should be an accompaniment of all learning, but the understandings which we strive to develop in the schools will vary in kind and in richness as widely as do other forms of desirable learning. Although the completeness of understanding we seek to engender may depend upon a number of factors, in general the more essential the need for any particular instance of learning, the greater the need for understanding. Finally, if we would develop understandings, we must realize that the learning involved is in great part a function of the methods of teaching and evaluation we use. As learning itself becomes meaningful, through being purposeful and being built on a sufficient background of experience, and as judgments on the adequacy of learning come to be made from data which include evidence of understanding, understandings will come to be actual outcomes of education. The detailed treatment of the many problems relating to the evaluation of understanding is left for consideration in the next chapter.

CHAPTER IV

OBTAINING EVIDENCE OF UNDERSTANDING

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The importance of developing and appraising understanding was pointed out in chapter ii. A detailed discussion of the nature of understanding followed in chapter iii. The present chapter is concerned with the problem of obtaining evidence to show the degree to which understanding has been acquired. Nine general principles governing the evaluation of understanding will be presented and discussed.

A word of caution is appropriate at the outset. The proposals advanced in this chapter, when taken together, set for the teacher an ambitious and elaborate program for evaluating understanding. On this account they may easily lead to either of two extreme reactions. On the one hand, a teacher may be overawed by the requirements of an ideal program and, feeling that any effort on his part would be fruitless, do nothing at all about the assessment of understanding. On the other hand, the teacher who is exceedingly conscientious may undertake to do all that seems to be called for. In such case he will devote a disproportionate amount of teaching time to evaluation, leaving insufficient opportunity to help children *develop* understanding. Both of these reactions are undesirable. As previous chapters have indicated, understandings are crucial, and they should receive emphasis both in teaching and in evaluation; but this emphasis must be kept in proper perspective in view of the many-sided responsibilities which the teacher carries. It is unreasonable to expect any teacher to measure all understandings, or even to measure all aspects of single understandings.

PRINCIPLES APPLICABLE TO THE EVALUATION OF UNDERSTANDING

1. In every subject-matter area there are available at present many well-known procedures for the evaluation of understanding.

The evaluation of understanding does not, in general, require new devices and procedures. The teacher should depend upon normal classroom opportunities, the examination of pupils' work products, written tests of different kinds, pupil interviews, and the systematic observation of pupil behavior.

While the abundant literature on measurement makes it easier to write extensively about paper-and-pencil tests, it should be understood that the day-by-day observations of alert teachers provide the most significant evidence of pupils' understanding. This needs to be said, not simply because the written form of the examples that follow may make them seem to be test questions, but because the things which pupils do and say in the course of the regular daily program, when properly noted and interpreted, are the richest source of information about what pupils understand, and how the understanding is acquired.

As a matter of fact, some understandings are best assessed when they are assessed informally. Written tests and other formal instruments of appraisal make their unique contributions, but frequently the best evidence of a pupil's understanding is reflected in reactions that may escape the teacher's notice. There are, for example, many personal meanings, sensitivities, appreciations, and values (all involving understanding) which are closely guarded by pupils and which will not be revealed except when some situation engrosses them so completely that they forget themselves. The ordinary school day affords many such situations, and the occasions thus made available for observing significant behavior should be utilized to the full.

The teacher should not entertain the notion that evidence secured by observation is necessarily too nebulous and unreliable to provide a satisfactory basis for rating pupils. It is precisely by observation that these pupils will be rated later in life; and while observational evidence should not be used as the sole means of evaluation, it does have certain attributes of naturalness which make it correlate highly with postschool success.

During the past decade or so, considerable work has been done with respect to the possibility of systematizing teachers' procedures in taking notes on pupil behavior. For example, teachers are increasingly being urged to recognize the value of anecdotal reports of incidents

which reveal a pupil's personality traits, such as dependability, initiative, industry, or leadership. In the same or in a similar set of forms observational evidence of understandings may be recorded in an orderly fashion. Such behavior characteristics can be identified as they occur throughout the day and reduced to permanent descriptions at convenient intervals. These data then provide a substantial basis, not only for determining "grades" for pupils, but also for conferences with pupils, with the principal, or with parents.

2. To provide evidence of understanding, evaluation situations must contain an element of novelty, but not too much novelty.

This statement may seem to contradict a statement made in chapter iii, where it was pointed out that understanding frequently underlies routine reactions—performances carried through "without thinking." The apparent inconsistency is not a real one. In chapter iii the question at issue was the *nature of understanding,* and, quite properly, mention was made of the fact that understanding is reflected in much habitual behavior. In the present chapter, however, the problem is that of *securing evidence* of understanding. Behavior in familiar situations *may* be based upon understanding, but we cannot be sure that it is. On the other hand, effective and intelligent behavior in unfamiliar situations furnishes acceptable evidence of understanding.

The Need for Novelty. Much that passes for understanding in the school is primarily memorization. On the other hand, understanding is attested when the pupil dips into his knowledge and fits it into new patterns of thought or action which could not have been directly learned. For example, being able to recite a number of reasons why something happened is no real assurance that the person comprehends *why* it happened. He may not understand (sense the significance of) the reasons that he has learned. It is no more difficult for the pupil to learn reasons as facts than to learn names and dates as facts. Any genuine test of understanding will, therefore, require that the pupil show his ability to *utilize* knowledge (perhaps of relationships) to explain or interpret events in new situations or contexts. Accordingly, classroom questions and written tests which seek evidence of understanding should not emphasize reasons or supposed insights which have been taught and learned as facts, but should call for the use of abilities, both detailed and general, to cope with situations containing at least some novel elements.

As has already been suggested, class discussion offers many opportunities for setting new problems and new contexts. It must be

borne in mind, however, that the responses of children are affected by personality factors as well as by their level of understanding. The child who is always eager to respond and who may have good answers may not have any better understanding than does the child who never volunteers and who may even offer an inadequate response when called upon. The first child simply has his understandings in a form that is better adapted to social situations. While personality traits are important and while we should seek to cultivate good social adaptation, for the purpose of evaluating understandings it is necessary to separate the various elements which may enter into performance. It is, therefore, desirable to adapt the means of obtaining evidence not only to the kind of intellectual outcome sought, but also to the kinds of personality and behavior that are characteristic of particular children.

The employment of novelty in the evaluation situation is, in several fields, a matter of well-established practice. In mathematics and science the test of accomplishment is not the ability to repeat memorized relationships, but rather the ability to use them in solving "original" problems. In foreign language study, sight translation is the most acceptable evidence of ability to read. Tests of reading ability in English also include passages which are novel to the pupil. In geography, questions based on hypothetical maps may yield evidence of something more than memorization. In the social studies, "problems of democracy" may be presented in simplified form for solution, or at least for the identification of principles which would apply to their solution. And, of course, in creative writing, or in other areas of creative effort, practically the entire product is expected to be original and to some extent individual and personal.

This requirement of novelty underlies all appraisal of understanding and will appear in various special forms in the remaining sections of this chapter.

Danger of Too Great Novelty. But the evaluation situation must not be too novel; there must not be too great a gap between previous learning and the measurement situation. Performance breaks down when the situation is too unfamiliar, and one may not be able to utilize effectively the understanding he actually possesses. It is easily possible to create evaluation situations so foreign to the pupil's experience that he becomes confused and cannot make use of the understanding which would function in more normal situations. Hence, even in "novel" situations, a certain strong proportion of familiar elements must be present if responses are to be intelligent rather than random and chance reactions.

The degree of novelty to be represented by various factors in the evaluation situation is dealt with in detail in the following section, but at this point one concrete suggestion may be offered: The novel elements which are introduced for purposes of evaluation should be restricted to a single type at a given time. For example, in arithmetic, if the problem involves novel content, the process of solution should be familiar to the pupil. If, on the other hand, the process of solution calls for ingenuity or special insights, the content should be familiar.

3. Understanding is of many kinds and many degrees, and evidence is to be sought on appropriate levels.

The first half of this statement repeats an idea discussed at some length in chapter iii, where it was pointed out that situations differ in subtlety, in complexity, and in other ways. Not all pupils attain the same level of understanding with respect to a single situation; nor does any one pupil attain the same level of understanding with respect to all situations. These facts are of considerable significance for the problem of evaluating understanding. They explain why "evidence of understanding is to be sought on appropriate levels."

Variation in Subtlety and Complexity of Situations. It may be well to illustrate what is meant by different levels of understanding and by different kinds of understanding. Any of the questions in the following list might be asked in United States history after a study of the career of Ulysses S. Grant:

1. Who was the general in command of the victorious Union Army at the end of the Civil War?
2. What generals served under Grant at the Battle of Richmond?
3. During what years was U. S. Grant President of the United States?
4. (True or false?) General U. S. Grant's victories during the Civil War were an important factor in his being elected President.
5. (Multiple-choice.) An important factor in General U. S. Grant's election to the Presidency of the United States was
   a) his previous career in politics.
   b) his successful leadership of the Union Army in the Civil War.
   c) the fact that he was a Democrat.
   d) the fact that Abraham Lincoln had expressed a strong desire for Grant to be his successor.
6. Compare Grant's success as a general with his effectiveness as President.
7. In the light of your study of Grant's career, which of the following is the most reasonable inference?

a) Successful generals are likely to make poor Presidents.
b) A President who has been a successful general can make considerable use of his military experience in planning to deal with new social problems.
c) The fact that a man is a good general is no guarantee that he will make a good President.
d) It is not necessary for a man to be a successful general in order to be a good President.
e) Success as a general may reduce a man's prospects of being elected President of the United States.

8. What evidence is afforded by United States history concerning the likelihood that a man who has been a great general will later become a successful President?
9. By citing examples from different countries and different periods of history, indicate whether the preponderance of evidence supports or contradicts the claim that successful military leaders make effective political leaders.

While some of these questions are phrased for paper-and-pencil tests, they could all be adapted to oral discussion. Regardless of the form they may take, their merits for the evaluation of understanding may well be examined.

The first three questions are simple questions of fact. The first question calls for information which the average citizen might be expected to have acquired in his schooling and is, therefore, an appropriate question when used in a test covering facts and understandings at an elementary level. The ability to answer this question is not, however, evidence of useful understanding. The information sought in the second question is of quite limited value to most students. Only a specialist in military history would likely be able to relate this information to other facts in any significant way. The third question relates to a detail of chronology of little importance by itself and consequently tends to encourage undesirable methods of teaching and learning. Only a historian with a wealth of related knowledge would be appreciably served by the ability to summon up this detail.

Question four may be assumed to require understanding of an elementary kind. If the answer had not been taught directly, this question might be used, together with similar questions, to test an elementary level of understanding. Question five makes it necessary for the pupil to weigh alternative explanations of cause and effect. Again if the answer has not been taught directly, the exercise compels the pupil, on the basis of his knowledge, to reject several plausibly stated

possibilities in the process of choosing the correct explanation. Question six requires the summoning and stating of facts and the pronouncement of a simple judgment. If not directly taught, the correct answer to this question reflects elementary understanding.

In question seven the pupil is asked to carry out a process of thinking that requires a fair amount of knowledge about Grant's career as well as considerable understanding both of the facts involved and of the logical inferences that may be drawn from them. This is particularly so because some of the statements might be regarded as true in general but cannot be deduced from knowledge of Grant's career.

Questions eight and nine necessitate successively broader knowledge and understanding of military, political, and social history, together with an ability to express the understanding effectively. Maturity of thought may be disclosed in the pupil's ability to hold himself to the precise conditions set by the questions and to suspend judgment when the evidence is not clearly in favor of one conclusion or another.

In sum, the appropriate answers to this series of questions illustrate gradations of understanding which extend from factual memory, through relatively elementary understanding, to a degree of mastery approaching that of the scholar-specialist. In the type of appraisal here exemplified we are primarily concerned with *relations*. It is clear from the illustration that the understanding of relationship may vary greatly in breadth and richness. It should be clear, as well, that evaluation must be planned with full awareness of this variability and directed toward an appropriate level.

Variation in Intellectual and Social Distance. From the standpoint of learning—and so, from the standpoint of evaluation as well—situations differ not alone in the matter of subtlety and complexity of relationships as just illustrated. They differ also, among other ways, in remoteness, or in the intellectual and social distance the pupil may be called upon to span in his thinking or response.

a) *Intellectual distance.*—We may consider first the matter of intellectual distance, as typified in the following graded steps in arithmetic. After a pupil has learned to solve a particular problem, the first move away from complete reproduction is the application of the same method to a similar problem containing different quantities or different materials. Having discovered, for example, that multiplication will yield the answer when he wants to find how much six pencils cost at three cents each, the pupil may be asked to find how

much seven rulers cost at five cents each. At a higher step in the scale he may learn to determine the areas of pieces of paper which are immediately available for examination and manipulation. Here he uses multiplication in a new way and in connection with a concept (area) which is more abstract than pennies and rulers. Next, he may extend this use of multiplication to find the areas of large land surfaces which are verbally described, and hence are not subject to direct observation. Still further progress in intellectual remoteness, though in a different direction and perhaps coming before some of the steps just described, is made when the pupil becomes acquainted with the inverse relationship between multiplication and division. To illustrate: he proceeds from the understanding that he must multiply to find the cost of six pencils at three cents each to the realization that he must divide $2.80 by four to find the share of each of four boys whose expenses amount to that sum. As an extreme of the scale, problems may be set in wholly new situations, involving units or content the pupil has never encountered, but which he should be able to solve by some sort of analogy. For example, his understanding of multiplication may need to be applied to ratio and proportion in connection with problems based on Mendel's Law or with probabilities in coin tossing.

It is obvious that in the foregoing series of arithmetical situations the pupil has to react at points that are intellectually further and further removed from the simple, familiar situation represented in his first learning task. From the viewpoint of evaluation it would be a mistake to infer that understanding is demonstrated by successful performance in the last stage only. On the contrary, even the first stage in the series calls for some understanding, and each successive stage calls for added increments of understanding. The program of evaluation must be planned with full recognition of these facts. It would be absurd to assume that third-grade children are deficient in understanding because they cannot succeed with a task which appears well toward the end of the series; but no more absurd than to assume that eighth-grade children have evidenced the expected level of understanding when they succeed with tasks which occur early in the series. In a word, evaluation situations must be designed to provide just enough intellectual remoteness to evoke the level of understanding which should have been achieved.

b) *Social distance.*—In similar fashion, increases in social distance affect the degree of understanding called for. This statement

may be clarified through the use of a series of graded illustrations, this time in the field of social behavior.

Children may be taught to take turns with play or work equipment, and in other ways to be fair with members of their group. The first step away from the immediate learning situation occurs when the teacher has left the room temporarily, or when supervision is temporarily relaxed on the playground. The authority of the teacher or supervisor has been removed, but the pupils and the particular setting remain as familiar elements to sustain the learning. A second step in increased distance from the earlier learning situation occurs when individual pupils are at home, in the town library, at Sunday School, or at a Scout meeting, or perhaps when they are playing on sandlots. The original pupil group has now given way to groups in which at least some members are not classmates, and the external situation has been shifted, although it is still within the range of community living. A third level occurs when both one's companions and the external situation are new, as when one travels outside the range of his customary activities and is associated with new people. A fourth level is represented when familiar landmarks and personalities are all absent and only impersonal communication and attenuated forms of control remain. The acceptance of rationing of food and clothing and of other limitations imposed by a wartime economy is an illustration. Perhaps we should say that a fifth step is reached when one accepts with satisfaction the principle of extending to all people in all countries throughout the world equal access to the necessities of life—or at least to all people who will not grossly abuse the privileges accorded them. Lend-lease is the formal device which we have adopted during the war in recognition of this principle; we have not yet extended it to peacetime situations. Perhaps all of us can identify among our friends and acquaintances those who extend their understanding in these social matters only as far as one or another of the steps in the scale just outlined.

In passing judgment upon growth in social understandings the teacher will take care to obtain a variety of evidence, based on a number of situations, before coming to a conclusion about a given pupil. The teacher will desire reports from other persons, both in the school and without, such as parents, the town librarian, Sunday School teachers, Scoutmasters, and even pupils themselves concerning out-of-school incidents. Some teachers will object that the evaluation of such understandings lies outside their formal responsibilities. But they must be reminded that the goal of the public schools is to

make good citizens and not simply to make pupils competent in the school subjects.

Desirable Levels of Understanding. Since there is such wide variation in degrees of understanding, the teacher is confronted with the question: For what level of understanding should I strive? The answer to this question must be practical, based in large part on what it is possible to do. Theorists are prone to aim too high and to insist upon unattainable ideals. Their admonitions are often of little aid to the teacher who has to work with children of ordinary capacities.

For what level of understanding, then, should the teacher strive? The answer may be framed in terms of the series of questions about Grant (pp. 48-49). Teachers may well direct their efforts to the cultivation and the appraisal of the abilities called for by questions five and six. These questions require the pupil to incorporate facts into a pattern and to distinguish between the values and relationships of the facts in a large setting. The criticism of common educational practice is that too much teaching and testing have been pitched at the level of questions one, two, and three, with comparatively little concern for abilities at higher, more complex levels. A reasonable and desirable departure from this practice would seem to be to retain a fair number of factual questions of a justifiable character, such as question one about Grant, but to emphasize questions like five and six, and include a few of the type represented by question seven. As time permits, such questions as the eighth may be included in both class and test procedures.

If this proposal appears to set too modest a goal, especially for high-school students, it should be pointed out that concentration on questions like seven, eight, and nine in this list is bound to be disappointing, and the ultimate effect may be a reactionary acceptance of the old narrowly factual learning as the best that can be achieved. On the other hand, a moderate departure will not build false hopes, but will serve to focus attention on relations rather than on isolated and inconsequential facts.

Teaching and appraisal goals are subject to modification in accordance with the ability and experience of the class. If it is appropriate to test principally for understanding of an elementary level, exercises similar to questions seven and eight may be omitted and more of the simple questions of fact may be used. But care must be exercised to avoid slipping into the habit of stressing the importance of responses to such questions as two and three. Although they are easy to make and to answer, the knowledge these questions call for

will be useless—especially for pupils of limited ability. On the other hand, if the experience and ability of a class permit, emphasis may well be shifted to questions that require evidence of higher levels of understanding, though some simple factual questions of real worth should always be employed.

4. Procedures employed to measure understanding should provide evidence of appreciation of primary reality.

The last two sections have stressed the fact that evaluation situations should contain an appropriate amount of novelty, and should afford evidence that children can handle relations of various types and that their understanding extends beyond the bounds of immediate circumstances. The higher levels of understanding, it was shown, are revealed by ability to deal effectively with increasingly involved situations, or those intellectually and socially more remote from the learning situation. The "opposite face of the coin" with respect to understanding of this abstract sort is an accurate knowledge and appreciation of the concrete realities which form the basic elements of relationships. Evaluation should be planned so as to include evidence that children know and appreciate these primary data.

The pitfall to guard against is mere verbalization, which often passes for understanding. It is all too common for pupils to pass all the tests in a course without really knowing "what the subject is." A pupil may be able to state that "stone is obtained from quarries," but further inquiry may disclose that when he speaks of a quarry he has in mind the idea of an aquarium. In mathematics, many pupils move on into algebra and higher branches and gain a mastery of the techniques of solving formal problems in these areas, while growing progressively less able to deal with real problems that can be solved by arithmetic.

The pupil who responds that Grant was a successful general but a poor President may have very erroneous ideas of the nature and degree of Grant's success in either role. In the traditional notion of a military hero, he may picture Grant as a brilliant strategist winning battles against overwhelming odds of manpower and materiel. On the other hand, he may picture Grant as a President who usurped power after the manner of a dictator and was nearly impeached, in this last detail confusing Grant with his predecessor, President Johnson. His appreciation of how Grant's success as a general led to his election as President may be meager and quite unrelated in his thinking to recent attitudes toward General MacArthur.

Sample Procedures. In appraising understanding, then, the teacher must be careful that abstractions and generalizations are not attained at the sacrifice of appreciation of primary reality. Of great value here is the follow-up question in classroom discussion or in interviews, to ascertain with certainty whether the pupil really grasps the meaning of terms he uses, events to which he refers, or units in which he expresses his answers. Ability to identify pictorial representations of geological formations, art objects, or animal life is one type of evidence to be used in classroom appraisal or in written tests. Ability to give specific examples of general terms is another type of evidence. If a pupil uses the term "Slav," let him cite national groups that are Slavic; if he speaks of citrus fruits, let him name some fruits that are citrus and some that are not; if he speaks of Romance languages, let him make it clear that he does not identify the term with modern European languages in general (including German). In mathematics, let the pupil be required constantly to refer his newly-learned skills to real situations in which they may be used, maintaining his elementary skills by frequent application even while learning higher skills.

The same principle holds in the case of understanding which involves social behavior and attitudes as, for example, learning to obtain satisfaction in taking turns in games and in the use of materials. Here teachers should not encourage progress in the direction of more distant, complex, and abstract relations without at the same time maintaining and intensifying satisfaction in primary situations. For example, the pupil who readily espouses rationing, lend-lease, and international co-operation, yet fails to *enjoy* taking turns and sharing in more immediate situations, is building on shifting sands. This tendency should be checked, and the favorable appraisal that is given to the appropriate attitudes of pupils in ordinary situations should be withheld. It is not enough that pupils accept remote ideals, especially when their satisfaction in immediate situations lacks spontaineity and appears to be dependent on receiving approval. The proportion of pupils of this kind will generally be small, but this fact is no excuse either for neglecting them or for giving them full credit for idealism. They should be given special guidance to prevent a psychological growing-away from reality. Understanding of international good will should be grounded in an appreciation of good will in primary face-to-face relationships.

Both in teaching and in evaluation, emphasis upon reality must be kept in balance. If pushed to an extreme, it will defeat its own

purpose. It can readily degenerate into exaggerated concern about facts, about definitions, and about verbalizations in general. Children should not be allowed to develop a fearful attitude, an attitude of not daring to go ahead lest they be vulnerable at points which are actually insignificant. Some caution in pupils is appropriate, but so also are purpose and courage.

5. Since intelligent behavior in many situations involves the ability to recognize the relevancy and sufficiency of data, evidence of this ability should be sought.

One phase of understanding is represented in the ability to determine the relevancy and sufficiency of data, material, or behavior for a given purpose. Life situations commonly require a degree of understanding that enables the individual to identify and find the data necessary to solve his problems. The effective person in life must have the ability not only to recognize a need for information but also to determine what data will best serve his purpose, as well as the ability to apply and interpret the selected data in relation to both familiar and novel situations.

Common Neglect of Principle. Textbooks and tests too frequently fail to require the pupil to demonstrate any comprehension of relevancy. It is common in stating problems in mathematics and science to give just enough data to solve the problems; no more, no less. A supervisor reports visiting a class where pupils were doing individual seatwork problems and going to the teacher for confirmation of their solutions. When one pupil came up, the supervisor heard the teacher say, "Of course it's wrong. You didn't use that number, did you? Well, they wouldn't give it to you if you didn't need it." Life sets few textbook problems. Data abound. The successful person recognizes crucial data and rejects other material as irrelevant to his purpose.

Sample Procedures. A beginning has been made in isolating this type of evidence of understanding for special appraisal. The Gans-Lorge Test of Critical Reading[1] describes situations in which the pupil needs to read to obtain information, and is then asked to mark several accompanying paragraphs as "Helps" or "Does not help." In one exercise a class is described as studying China when the suggestion is made that they give a Chinese party for their parents at which Chinese food will be served. Among the accompanying paragraphs to be read and evaluated for helpfulness in deciding what to serve are

[1] Published by Bureau of Publications, Teachers College, Columbia University, New York 27, New York.

some about food but not Chinese food, some about China but not about food, some that give fanciful fables about Chinese life, and some that tell of Chinese food, its preparation and serving.

Mathematics Progress Tests prepared for use in the schools of New York State include exercises like the following:

> Read each problem below and the facts which follow it. Decide what facts you need to solve the problem. After each fact you need, write YES. After each fact you do not need, write NO. Then answer the question "Do you need more information?" by writing YES if you need more information, or NO if you do not.
>
> How much money do Jack and Fred have together?
> (1) Jack has 10 cents.
> (2) Fred has 15 cents.
> (3) Do you need more information?
>
> How much change did I get from the storekeeper?
> (1) I bought 15 cents worth of candy.
> (2) I gave the storekeeper 25 cents.
> (3) I put the change in the bank.
> (4) Do you need more information?
>
> How far did Mr. Day travel on his trip?
> (1) He left Monday morning and returned Wednesday evening.
> (2) He drove 87 miles on Monday.
> (3) He drove 42 miles on Tuesday.
> (4) Do you need more information?

In the Social Problems Test prepared by the Evaluation Staff of the Eight-Year Study of the Progressive Education Association, pupils are given short descriptions of fundamental social problems such as those pertaining to housing, conservation, capital and labor, and race relations, and are asked to choose from sets of reasons those which support each of three proposed solutions of each problem. In addition to reasons that are valid, several slogans which are mere reiterations of the solutions, rather than being reasons, are offered for selection or rejection.

In all the tests described above, the pupil accepts or rejects material as relevant or irrelevant to a purpose. Similar exercises may be arranged in connection with projects upon which children are at work. The act of choosing appropriate matter and rejecting inappropriate matter may also be assessed informally in class discussion or pupil interviews. An excellent framework to use frequently, and one for pupils to develop as a habit of thought, is "What do we need? Do we have it? Where can we get it?"

Class projects and school activities abound in opportunities to present this challenge. Scouting and other camping experiences give rise to countless occasions for observing and evaluating, as well as for helping individuals develop the habit of making choices with discrimination. Such occasions are natural and normal; hence, they present problems of selection and judgment that are typical of life.

While selection of appropriate data or behavior is crucial in life situations, life commonly requires the individual, after choosing his data or behavior, to use them to solve complete (real) problems. For this reason problems which involve only decisions of relevancy should be supplemented by problems which demand finished solutions or a full treatment of data.

6. Evidence of understanding is to be found in originality of performance on the part of pupils.

This discussion of the evaluation of understandings would be incomplete were no mention made of the understandings which are involved in the freer area we call creative effort, and which, in the lives of all of us, find some expression in the pattern we choose to carry out. Understanding of the type referred to here is involved in the attempt to write an original poem or piece of fiction, in the painting of a landscape which is something more than the photographic likeness of what is seen, in the drawing of a cartoon to illustrate the point of a paragraph, in the selection of one area of work rather than of another area of work as a vocation.

In all creative work—and this includes the making of personal choices—there is the necessity for a fairly clear understanding of goals. Unless one has something in mind which is more ultimate than the immediate thing one is trying to judge, the many decisions which must be made will not be characterized by consistency. The concept of what one ultimately desires must naturally undergo many changes in the process of working toward it, but we do not expect pupils beyond the primary grades to start drawing on a piece of paper with no idea at all of what they want to draw.

In the same sense, in the larger sphere of life's choices, we expect each individual to have a growing purpose. His interests and his determinations and decisions should have some coherence, and this can be obtained only through relating them to a general goal.

There is another important type of understanding involved in creative work and personal choice. This is a sort of cause-effect understanding. In art, it involves the prejudgment of what a certain line,

or color, or detail of composition will do to the total pattern when all of the rest of the material has been put in. In creative writing the same problem is involved. In planning one's life there is the constant necessity for understanding what the consequences of a particular choice will be.

The ability to produce an alternate proof in geometry, distinct from one given in the text, calls for greater understanding than does the ability to follow a given set of steps. The ability to produce new elements of order in material where these have not been given by the text calls for more understanding than does the ability to grasp them when presented by others. Creativeness and pioneering in any of the classes of learning demand more understanding than simply following along.

Difficulties of Evaluation. In the area of understandings here under discussion there are few simple rules and few fixed guides that afford more than fragmentary help in evaluation, and the most creative persons may reject even these. Decisions made in this area involve something of the individual's personality—something of his interpretation of life and of its large values. For these reasons the precise evaluation of original and creative behavior is difficult.

The first step in evaluating such behavior in the school—a step without which evaluation is impossible—is to provide a classroom atmosphere which is conducive to creative and original work on the part of pupils. This means that some features of the school program will be freed from relatively rigid controls and that self-expression will be actively encouraged. When this step has been taken, the teacher will at least have *opportunity* to observe original performance in the classroom.

Since freedom and stimulation are of utmost importance in creative work, teachers must guard against the use of evaluative measures which may prove to be repressive and restrictive. What has happened to the appreciation and enjoyment of literature in the schools, under the influence of ordinary written tests and intellectualized objectives, is an all too familiar story: The fundamental goals have generally been lost sight of. The creative, interpretative spirit, when straight-jacketed, is killed. It must have the chance to live and grow and to be individual and personal.

The significant fact is that society will evaluate each individual's performance; and this fact should be made plain to every pupil. The teacher's role is to attempt to view the original performance of each pupil as it will be viewed by society—or, more accurately, as it will

be viewed by some segment of society, for nearly always there are wide variations in the evaluations of different persons and groups. The teacher will accordingly keep in mind that the final criteria for interpretive, original work are the pleasure and satisfaction of the individual producer and the acceptance of his work by certain groups of persons. The teacher may best serve the purpose of encouraging creative activity by gradually making clear to the pupil (*a*) the characteristics of work likely to be most acceptable to people in general, (*b*) the groups or kinds of persons who will be interested in particular elements (e.g., conventional form, daring individuality, subtle emotions, intellectual aspects), and (*c*) the fact that he (the pupil) will have to come eventually to rely on his own prejudgment of the value of each step in his work. Evaluation by the teacher should be an appraisal of the degree to which the pupil has developed these understandings.

7. Evaluation procedures should be selected with due regard for the likelihood of their evoking evidence of the kind of understanding that is required.

No one type of procedure has a monopoly of advantage for the purpose of securing evidence of understanding. This statement holds true in spite of the common practice among schools of relying almost exclusively upon paper-and-pencil tests. Throughout this chapter the values of other procedures—observation of significant behavior inside and outside the classroom, interviews with pupils, examination of work products, and so on—have been stressed in the hope of encouraging more general use of these procedures. Each type of procedure has its peculiar merits, and all should be employed in reasonable proportion.

In so far as paper-and-pencil tests are used, the measurement of understanding does not depend on any one type of test item. While it is true that each type of question is based on certain psychological considerations and that some types are more useful than others in evaluating understandings, the teacher has a wide choice of materials and procedures in constructing tests for this purpose. Essay questions and multiple-choice questions seem most easily to fit into the plan of such testing programs, but true-false questions are also highly adaptable. Simple recall questions, completion items, and identification items are likely to be of less value.

If one has equal facility in making both essay questions and objective questions, and if one is testing for an outcome which will fit

readily into either form of question, the choice will probably be made on the basis of the number of individuals who are to be tested. That is, in a test which is to be used only for a single class, essay questions would normally predominate because of the very great labor of devising an appropriate number of good objective test items. Where essay tests are used, however, it is important that the teacher express the question in sufficient detail that it will be clear, and in such form that it will indicate to the student the desired structure of his response. Many essay questions are unconscionably poor, perhaps because it is easy to ask enough questions to keep the pupils busy for the allotted time. But the teacher should not assume that good essay questions can be prepared without time and careful thought.

8. In obtaining evidence of understanding, care should be exercised to insure that the pupil's response reflects his actual level of understanding.

This statement means, essentially, that the pupil must perceive clearly what it is to which he is expected to react. Otherwise, the response he does make will not furnish evidence of his characteristic or true understanding.

Recognition of this principle is implicit in all that has been said in this chapter. It was explicitly enunciated in the discussion of the effects of excessive novelty in the evaluation situation. Accidental success may erroneously be taken as proof of understanding, or failure may be regarded as proof of lack of understanding, when in reality some spurious element is the real deciding factor. For this reason attention is called in this section to several other factors which may affect the reliability and significance of pupil responses.

Naturalness in the Evaluation Situation. Naturalness rather than trickiness should be the aim in framing questions for discussion or for tests. This point is particularly important in the selection of test items. A test is not an effort on the part of the teacher to outguess the pupil; nor is it intended that the exercises should be in such unusual form that the pupil is likely to be misled. This does not mean that all exercises should be easy, but rather that exercises and tests in the school are but substitutes for life situations in assessing the practical abilities which need to be used. The more that tests can take on the characteristics of normal situations, the better.

Clearness in Directions to the Pupil. The best guarantee that the pupil will know what it is to which he is supposed to react is to provide simple and clear directions, especially in the case of tests. Com-

plicated directions may require "higher" mental processes for their understanding and application, but the difficulty and novelty of a test should reside in the individual exercises rather than in the understanding of the directions. A teacher is interested in the question, "When a pupil understands fully what he is to do, how well can he do it?" A test of the understanding developed in a certain subject field is not a general intelligence test; it is concerned with the understanding of a particular body of definite principles and relationships in a given field.

Grouping of Items in Tests. It has sometimes been suggested that when objective tests are used for evaluation the items should be arranged in random order with respect to the topics or the content covered, so that each exercise is a "fresh" and independent challenge. Such deliberate scrambling of items is undesirable. In life situations one normally dwells on thought-provoking material for some time and is not required to shift attention spasmodically from one thing to another. Any emphasis on instantaneous reactions to mixed items is unfavorable to thoughtful response. It places a premium on adaptability of thought processes quite beyond the ordinary demands of thoughtful response. Instead, test items should be ordered in a logical manner. A test should start so far as possible with easy items, but the items should be definitely grouped around areas of subject matter so that the mind can "warm up" on each area and thus be enabled to function to full advantage. If some test items are found to provide clues for the answers to neighboring items, the matter can be remedied by changing some of the items to cover more varied aspects of the area to which they relate.

9. The program of evaluation should be planned so as to foster the development of habits of self-appraisal on the part of pupils.

In life situations we do not always have at hand some "expert" (as the teacher) to evaluate our behavior and to tell us whether we have acted wisely and appropriately. Indeed, if we are mature and competent members of society we do not *want* any such external authority to pass continually upon the quality of our performances. We recognize the need for a relatively high degree of independence, and we insist that to a reasonable extent self-appraisal is our right and our responsibility. Acceptance of these views imposes upon the school the responsibility of developing in children both the habits and the abilities of self-appraisal.

Partly because of the fact that many of the subtler outcomes of learning (such as understandings) are difficult of appraisal, and partly

because it is desirable to educate pupils away from a goal simply of striving to please the teacher, it is important, certainly by the middle elementary grades, to begin the development of self-appraisal. The beginnings should be moderate, but it is an important part of a pupil's growth that he learn to look at his accomplishments with some perspective. Such growth is an essential aspect of the pupil's understanding of the evaluations which other people throughout life will place upon his performance.

Sample Procedures. The ability to check one's solutions in arithmetic and thus to know that they are correct is an elementary step in the process of acquiring the habit of self-evaluation. At the completion of projects, mutual criticism of products and of presentations by the pupils themselves lays a groundwork for judgment other than that emanating from the authority of the teacher. Having pupils keep records of their progress from test to test or from year to year, especially if these records involve plotting curves and profiles of achievement, will contribute to the same end. Active participation by pupils in the preparation of their home reports is another useful practice.

Dangers To Be Avoided. In attempting to reach the objective of pupil self-appraisal the teacher should avoid certain dangers. It is not desirable to ask pupils to mark their own papers and then submit the marks for the teacher's revision. Under such circumstances personality traits loom large, and the mark which is submitted to the teacher may not represent anything like the evaluation which the pupil really places upon his work. The conscientious but shy pupil may place his mark two or three grades lower than he really thinks it should be, and the aggressive pupil, or the one with a different sense of integrity, may adopt the opposite procedure.

Neither should the teacher exploit the work of certain pupils by holding it up as a model before other members of the class. If pupil models are needed they should be taken from other classes. The teacher can, however, do constructive work by emphasizing criteria which are definite and specific. Clear goals are important, not only for the pupil but also for the teacher, and they are as valuable in guiding teaching and learning as they are in appraising the outcome. Some of the most effective teaching will consist simply of the exposition of social goals and ideals, either to the group or to the individual pupil.

The teacher should avoid such emphasis upon self-appraisal that the pupil's attention is drawn away from actual doing and learning.

Only a minimum of introspection is desired. Adults who act courageously and independently, relying on their own judgment and understandings, are likely to be persons who, as children, were encouraged rather than merely rated by others. The best justification of self-appraisal as a goal for children is that it contributes to their social understanding—that they live and work in a world of people, and that if they are to be successful they must understand themselves and be able to anticipate the reactions of other persons to their behavior.

Summary

To summarize the chapter as briefly as possible, the nine principles which have been presented for obtaining evidence of understanding are here repeated:

1. In every subject-matter area there are available at present many well-known procedures for the evaluation of understanding.
2. To provide evidence of understanding, evaluation situations must contain an element of novelty, but not too much novelty.
3. Understanding is of many kinds and many degrees, and evidence is to be sought on appropriate levels.
4. Procedures employed to measure understanding should provide evidence of appreciation of primary reality.
5. Since intelligent behavior in many situations involves the ability to recognize the relevancy and sufficiency of data, evidence of this ability should be sought.
6. Evidence of understanding is to be found in originality of performance on the part of pupils.
7. Evaluation procedures should be selected with due regard for the likelihood of their evoking evidence of the kind of understanding that is required.
8. In obtaining evidence of understanding, care should be exercised to insure that the pupil's response reflects his actual level of understanding.
9. The program of evaluation should be planned so as to foster the development of habits of self-appraisal on the part of pupils.

SECTION II

PROCEDURES FOR MEASURING UNDERSTANDING IN DIFFERENT SCHOOL SUBJECTS

FOREWORD TO SECTION II

THE YEARBOOK COMMITTEE

Before turning to the subject-matter chapters, the reader is entitled to a few words of explanation. Without this explanation he might easily misinterpret both what he finds and what he does not find in the various chapters. The following paragraphs are, therefore, intended to provide orientation and to forestall potential misunderstandings.

1. To the fullest extent possible, responsibility for the chapters of Section II was assigned to the various chapter committees. The yearbook committee undertook to restrict the purposes of these chapters to the general purpose of the yearbook and to assure a high level of quality for their content (not an arduous task in view of the competence of the chapter committees); but it did not try to dictate the material to be included or the form it should take.

In general, the procedure was as follows. Chapter committees submitted first drafts of their contributions. The yearbook committee scrutinized these manuscripts in the light of the purpose of the yearbook, asking themselves such questions as: (*a*) Does this objective clearly relate to understanding? If not, should it be omitted, or can it be framed in a more appropriate way? (*b*) Does this evaluation device actually get at the understanding in question? If not, can it be changed, or can a better device be found? (*c*) Has use been made of all evaluative devices (and not merely of paper-and-pencil tests) which can profitably be employed in the given subject-matter area? Chapter committees were furnished the criticisms of the yearbook committee; at the same time they were told that they had final authority to accept or to reject each suggestion—the chapters were to be *theirs*.

Chapter committees revised their manuscripts, which were again read and criticized by all members of the yearbook committee. A second letter of suggestions went then to chapter committees, once more

with the understanding that they were free to do as they wished with respect to the proffered suggestions. In some cases the second drafts, with minor changes, were accepted for publication. In other cases a third draft was prepared.

In view of these facts it should be clear that the major share of credit for the chapters of Section II belongs to the chapter committees.

2. Chapter iv, in which the yearbook committee expresses itself on the general problem of "Obtaining Evidence of Understanding," was not available to chapter committees until too late to be of much service to them. The nine principles governing the evaluation of understanding which are presented in chapter iv are not, therefore, to be regarded as the criteria in terms of which the chapters of Section II were consciously developed. Never having seen this statement of principles until after they had wholly or practically completed their own labors, the chapter committees can properly be bound by these principles only to the extent that they are sound and are generally applicable. The critical reader will, however, be impressed by the degree to which the yearbook committee and the chapter committees are in agreement with respect to practical procedures for evaluating understanding.

3. There is considerable lack of uniformity among the chapters of Section II. All chapters, except that on language arts, contain the two major parts, (*a*) a list of objectives which involve understanding, and (*b*) sample procedures for evaluating these objectives. Uniformity was required in this respect, but in few other respects. The list of objectives in some chapters is short, a half dozen or so expressed in broad, general terms; in others, the list is long, for the objectives have been analyzed in greater detail. In some chapters the objectives are considered in succession, and the sample procedures are subordinated to the objectives. In others, the evaluation procedures provide the basis of organization, and the objectives assume a subordinate relationship. Uniformity could have been secured, but perhaps at a price which would have made it too costly. The yearbook committee felt that each chapter committee should know best how to address the teachers in its subject area, and accordingly each committee was encouraged to adopt the form of presentation which, in its opinion, would be most effective.

4. Overlapping will be noted among the chapters of Section II. This overlapping is to be expected, for—to choose but a few examples—such pairs of subjects as home economics and health, science and agriculture, industrial arts and technical education have at certain points similar or identical objectives. The overlapping could possibly

have been avoided through the expedient of arbitrarily assigning this and that objective to some single specified chapter. To the yearbook committee this practice seemed unwise. It appeared better to let each chapter committee have its say even though to do so meant some duplication and perhaps some loss of space. In the end, it was felt, it was important for teachers to have as a unit in one place a systematic presentation of evaluation in their subject.

5. It would be a mistake to make invidious comparisons among the chapters of Section II on such issues as: the number of objectives recognized, the level of understanding evaluated, variety of evaluation procedures exemplified, and the like. The truth is that the subjects differ among themselves in the psychological complexity of the outcomes to be attained, in the extent and in the direction of research on evaluation, in the aspects of behavior which evidence understanding, and so on. The measurement of understanding is relatively easy in some fields and relatively difficult in others. Students of some subjects have for a considerable period of time devoted attention to the development and measurement of understanding, while students of other subjects have but lately become interested in these problems. In some subjects paper-and-pencil tests are more effective and more generally useful than in others, where understanding must be identified as a subtle aspect of some complicated activity on the part of the pupil. For these reasons the reader should withhold judgment, refusing to condemn the offering of some chapter committee merely because it does not seem to meet the standard set by some other committee. Rather, in examining the chapters let him look for what is valuable to him, what is new, what is suggestive.

6. In the space available it was impossible for any chapter committee, even the committees in charge of the longer chapters, to exemplify all possible evaluation procedures for all objectives as listed. Instead, each committee had to choose among the possibilities afforded by objectives and procedures and to limit its exhibit to those which could be fairly well dealt with in the allotted number of pages. For this reason it becomes the teacher's responsibility to adapt and to extend such procedures as could be illustrated. In doing so he may well ask himself such questions as: Can the excellent device suggested for Objective 3 be used for Objective 2, as well? What changes could I make in this device (say, for Objective 5) to make it serve for Objective 1? Can I enrich the evaluation situation here used in connection with Objective 7 so as to secure evidence also with respect to Objectives 4, 6, and 8? If the contents of the chapters of Section II

are used in these ways, the teacher will be able to do for himself what the committees did not have the opportunity to do for him, and in so doing will gain in his own insights and in the quality of his evaluation.

7. Also, space limitations often prevented the illustration of evaluation procedures for all grade levels. The subject committees recognized the necessity of adapting evaluation procedures to school-grade and pupil-ability levels, and the yearbook committee has discussed the point at length in chapters iii and iv. In some cases committees were able to designate certain procedures as suitable for either Grade V or Grade VIII; but this practice leaves the reader with the questions: Does the statement mean that I can use the procedure for my Grade VI children? If so, what changes, if any, must I make? If not, what can I substitute? Here again reliance must be placed upon the good sense and the intellectual and professional qualifications of the individual teacher to make up for the necessary limitation on the amount of illustrative material the chapter committees could provide.

8. It would be well for each reader to examine more than the one chapter which deals directly with his teaching specialty. There is enough in common among understandings as objectives in the different subjects to make the suggested evaluation procedures of general usefulness. For example, the teacher of the social studies can find much of value in the chapter on language arts, and vice versa; the teacher of science can find much of value in the chapter on mathematics, and vice versa. This practice, of reading several chapters (even of chapters which at first may seem to be only remotely related), offers one means of overcoming the handicaps of space under which the committees had to do their work. At the same time it assures the teacher a greater wealth of evaluation procedures than he could possibly secure from a single chapter.

9. No other limitation imposed on chapter committees was more disturbing to them than the lack of opportunity to consider critically the evaluation procedures which they illustrated. Many committees, for example, recommend the use of some form or other of rating scale. All these committees recognized full well the cautions which must be observed in order to insure the essential degree of reliability and validity of the proposed scales. Most committees also come out strongly for the use of the interview, of classroom questioning, and of both informal and standardized observation; and here again they realized the perils that reside in bias, in carelessness, in incompetence. Yet, they could not discuss these matters. Nor could they point out the special advantages of one method of evaluation, and the disadvantages of an-

other method. There were just not enough pages for use in these ways. To meet this need the one volume would have had to become two at least, and this was impossible. Instead, chapter committees were asked to restrain their urge to be critical and were promised this paragraph to relieve them of any blame for such omissions. Some chapter committees sought relief from this restraint by availing themselves of the opportunity to supply short lists of references in which, they hoped, their readers would find the cautions and admonitions which would have been presented in these chapters, but for the limitations of space. Added relief, too, may be furnished by the brief bibliography appended hereto, in which the yearbook committee undertakes to supplement the chapter bibliographies for the benefit of the interested reader.

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CHAPTER V

THE MEASUREMENT OF UNDERSTANDING IN THE SOCIAL STUDIES

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OBJECTIVES OF SOCIAL STUDIES

The objectives of instruction in the social studies have been stated and restated by experts and by scholarly committees working in this field. Limitations of space make it impossible to cite these statements at length or to make clear the ways in which they differ from one another.[1] It is sufficient here to point out that there is general agreement on three broad goals which are directly related to the development of understandings:

A. Acquiring functional information
B. Analyzing social problems
C. Practicing desirable social relationships

For the purposes of the present discussion, twelve specific objectives are suggested as representative of the most important aims of instruction in the social studies. Although these are distributed as subtopics under the three broad goals enumerated, it should be clearly understood that these three categories are not mutually exclusive.

[1] The reader is referred to the following references in the bibliography at the end of the chapter: **1**; **3**; **4**: chaps. vii-x; **11**: chaps. ii-v; **13**: chaps. v, xv; **21**: chaps. ii, iii; **15**; **22**; **23**; **27**: parts I, IV; **32**; **35**.

Acquiring Functional Information

The sources of information in the social sciences may be classified as follows: (1) written records such as documents, books, newspapers; (2) pictorial representations such as pictures, maps, graphs; (3) oral records such as speeches, broadcasts, recordings; (4) remains such as tools, weapons, coins; and (5) the social scene itself. Actually some sources of information combine the characteristics of two of the categories just listed. A sound film, for example, combines pictorial representation with the spoken word; a map includes a certain amount of printed information, and so on.

The discussion in this section considers only certain types of understandings involved in using sources, and it represents a purely arbitrary segregation for convenience in discussion. Actually the material included in this section might just as well have been included in the treatment of "Analyzing Social Problems." It is important that pupils in social-studies classes understand written and oral presentations of social problems. This chapter is not the place, however, for a consideration of all the abilities needed for the comprehension of materials presented orally and in writing. Indeed, the discussion of the first "broad goal" mentioned above will be limited to a consideration of four objectives which are of particular importance:

1. Understanding the special vocabulary of the subject
2. Understanding chronological relationships
3. Understanding maps
4. Understanding graphs and tables

Objective 1: *Understanding special vocabulary.* There is little need to elaborate on the first of these objectives; the other three, however, will be developed in sufficient detail to suggest kinds of evaluation which are appropriate.

Objective 2: *Understanding chronological relationships.* Chronological information is conveyed by numbers, by words which have numerical meaning, and by graphic representation. The last means need not be considered at this time since it is discussed in a later section (p. 84 f.). Perhaps it should be added that historical chronology need not be conceived entirely in numerical and spatial terms. A knowledge of events will make clear a great many relationships of order and duration; indeed, if a pupil knew enough history he would not find it necessary to rely much on dates, i.e., numbers (**34**: 33 f.).

When a pupil depends on dates for chronological relationships he must be able to arrange numbers in order of size if he is to understand the sequence of events. In this way he can choose any date-event as a

reference point and determine whether other events happened earlier, later, or at about the same time. He must also be able to subtract and to add in order to tell, for example, how long a certain man lived or when another man died, such essential facts as date of birth being known. The pupil also needs to understand the duration of time between two date-events. For example, the statement, "the First World War (1914-1918)," makes clear that the First World War lasted from 1914 to 1918. Anything which happened between these dates, as the re-election of President Wilson in 1916, happened during the First World War.

Given a single date-event and information about other events, it is possible to infer generalized chronological relationships between the date-event and events which are not specifically located in time. For example, if the statement were made that Woodrow Wilson was re-elected President in 1916 after a campaign in which he claimed that he kept the United States from going to war with Germany, certain inferences could be made:

> Woodrow Wilson was first elected President in 1912.
> A war involving Germany had raged during his first term, i.e., before 1916.
> This war was not over by 1916.

Given a certain amount of information, plus a general knowledge of history, a reader may be able to infer the date when an event occurred. For example, a pupil might figure out about when John Quincy Adams made the following entry in his diary: "Had an interview with M. de Neuville about our affairs with Spain. He says that Spain will give Florida to the United States for the debts which are owed to our citizens." Certainly that entry could not have been made in 1820 or later, and it is unlikely that it was made many years prior to 1819.[2]

Objective 3: *Understanding maps.* In reading a map the pupil must interpret concepts which depend directly on an understanding of scale, network, and symbols, as well as those which depend on an understanding of interpretative ideas derived from scale, network, and symbols (8: 24 ff.). The following outline suggests the variety and range of understandings involved.

1(*a*) Relative location. City *A* is located north of the equator. All of country *E* lies west of the prime meridian.
(*b*) Exact location as expressed in latitude and longitude.
(*c*) Interpretative ideas. When it is 3 P.M. in City *A*, what time is it in City B?

[2] This discussion is based on material in Wilmeth's dissertation (34: 36-81).

2(*a*) Relative distance. Iowa is longer from east to west than from north to south.

(*b*) Exact distance as indicated by scale or degrees of latitude. (The pupil should also know when he cannot use a scale to determine distance.)

(*c*) Interpretative ideas. Which city (*A* or *B*) has fewer hours of daylight in January?

3(*a*) General or relative direction, determined without use of map network. City *A* is at the south end of the island.

(*b*) Exact direction, determined by using map network.

(*c*) Interpretative ideas. What direction would you travel in going directly from City *A* to City *B*? (Pupil might be asked to answer this question after looking at different projections, e.g., a Mercator, a Mollweide, and a polar projection.)

4(*a*) General concepts of areas.

(*b*) Exact concepts of area gained from network.

(*c*) Interpretative ideas. Is the United States the largest country in the world?

5\. Advantages and limitations of various projections. How accurately does each projection show distance, direction, and area? For example, is Greenland larger than Brazil? (Compare Mollweide and Mercator.)

6\. Symbols.

(*a*) Natural features, e.g., land, water, rivers, mountains, etc. Both City *A* and City *B* are on the equator. Which will have the cooler climate? (Interpretative idea involving knowledge of how altitude affects climate.)

(*b*) Human features, e.g., cities, roads, canals, railroads, etc. Why have some political scientists argued that state boundaries interfere with the efficient government of metropolitan areas?

(*c*) Distributions and utilizations, e.g., rainfall, resources, population, etc. Why are the farmers in State *A* likely to raise hogs?

Objective 4: *Understanding graphs and tables.* In this chapter it is not possible to take into account the variety of graphic representations found in materials used in social-studies classes. The following list merely suggests some of the major types of understanding involved in reading graphs and tables (**21**: 45 ff.): (*a*) interpreting the legend, (*b*) finding an item of information, (*c*) comparing two or more items, (*d*) recognizing a trend, (*e*) comparing trends, (*f*) restating information in one's own words, (*g*) making simple computations, and (*h*) making predictions from given data, as in extrapolation and interpolation.

Analyzing Social Problems

Some years ago the Committee on Social Studies of the Progressive Education Association made an effort to enlist the co-operation of

social scientists in determining "(1) what social problems are likely to offer the most serious challenges to Americans now in secondary schools; and (2) what social-science concepts, generalizations, and findings promise to be most helpful in the solution of such problems" (**23**: 24). This task was never completed because it would have required the expenditure of greater resources than were available to the committee (**23**: 24 f.). Although the committee published a report which outlined broad areas for study (**23**: 116-311; cp. **4**: 195-225), areas which would meet the needs of adolescents, it nevertheless advised teachers that they, themselves (and their pupils), must assume responsibility for selecting the problems to be studied as well as for determining what information should be focused on those problems.

Objective 5: *Knowledge of important concepts, generalizations, and findings as a prerequisite to reaching valid conclusions about social problems.* The authors of this chapter regret that it is not possible to describe precisely the important "concepts, generalizations, and findings" which pupils should master at various grade levels. A recent attempt in this direction in the field of American history was made by a committee representing the American Historical Association, the Mississippi Valley Historical Association, and the National Council for the Social Studies (**31**).

The general sources of information upon which the social sciences (and indirectly the social studies) draw and some types of functional information which are of special importance to pupils in the social studies, however, have been listed in an earlier section of this chapter (see pp. 72 ff.). In the second part of this chapter, which is devoted to the presentation of evaluation materials, sample exercises will be included to illustrate procedures for evaluating the understanding of "concepts, generalizations, and findings" in areas other than those specifically mentioned.

If the pupil is to learn how to reach valid conclusions about social problems, he not only must master certain elements of functional information, but also must develop some proficiency in the techniques of inquiry used by social scientists. By those means he will be able to locate the additional information needed in analyzing a given social problem. A pupil who has reached valid conclusions about a given social problem also has a rational basis for "dealing effectively" with it. Much of the instruction in the schools, however, stops short of social action and many of the problems considered by the pupil both in and out of class do not permit him "to do anything about them."

The teacher who is interested in helping a pupil develop the ability "to reach valid conclusions on social problems" or "to deal effectively

with social problems," will find helpful suggestions in various works which describe teaching and evaluation procedures in the field of critical thinking.[3] In this chapter it is possible only to list the steps, i.e., the subobjectives, involved and to describe them sufficiently to suggest appropriate procedures for their evaluation. The scheme of classification is logical and to some extent artificial. There is no intention of suggesting that each "step" is taught in isolation or that each "step" must be taught in the order given. Moreover, it is neither possible nor desirable to insist on a segregation of "steps" in evaluation. The behavior of pupils in and out of the classroom provides a great deal of information which must be taken into account, and it is the rule rather than the exception that such information relates to more than one of the "steps of critical thinking."[4]

Objective 6: *Locating, selecting, organizing, and evaluating information.* The variety of understandings involved in locating, selecting, organizing, and evaluating the information bearing on a given social problem is suggested in the following outline:

1. Defining the problem and the terms used in the statement of the problem
2. Using a variety of appropriate sources
   a. Recognizing the variety of appropriate sources and taking into account their comparative availability
   b. Knowing how to use various types of sources efficiently. For example, in using
      1) Written records
         a) Understanding how to use card catalogs, bibliographies, abstracts, etc.
         b) Understanding how to use an alphabetical arrangement, an index, a table of contents, etc.
      2) Pictorial representations—knowing how to interpret maps, tables, graphs, etc.
      3) Remains—knowing art periods and handicraft types, for example.
      4) Social scenes—knowing how to prepare questionnaires, conduct polls, hold interviews, etc.
3. Selecting information which is pertinent in thinking about a problem
   a. Choosing information which is relevant; discarding that which is irrelevant
   b. Determining the validity of the relevant information
      1) Understanding the meaning of the information
      2) Getting the worth of the information as evidence by taking into account such factors as

[3] See **9**; **11**: chaps. iii, iv; **13**: chap. xv; **21**: chaps. ii, iii; **27**.

[4] The organization used in the following discussion has been adapted from materials prepared by a number of authors. See **27**: 1-47, 123-74; **28**: 65-131, 133-82; **33**.

a) Opportunity that person giving evidence had to make accurate observations
b) Competence of observer in the field in which he is giving evidence
c) Objectivity of observer, i.e., whether or not be is biased
d) Representativeness of data cited as evidence
e) Need for separating fact from opinion
f) Need for identifying value judgments implied in statements of opinion. These may color the reporting of facts, too.

4. Organizing information in a way to facilitate the reaching of valid conclusions
   a. Recognizing the essential aspects of the problem, i.e., preparing an outline to be used in studying the problem
   b. Knowing how to take notes
   c. Distinguishing between main points and supporting detail
   d. Arranging major elements or ideas in proper sequence

Objective 7: *Drawing conclusions and stating them effectively.* The variety of understandings involved in drawing conclusions from pertinent information on a given problem is suggested in the following outline:

1. Relating and comparing specific facts with each other
2. Recognizing the limitations of the data
3. Formulating accurate inferences and tenable hypotheses
4. Avoiding logical fallacies
5. Recognizing the value patterns which underlie the conclusions reached
6. Stating the conclusions reached in acceptable form by:
   a. Defining terms
   b. Pointing out underlying values
   c. Supporting conclusions with pertinent evidence
7. Being alert to recognize new evidence and willing to reconsider conclusions reached
8. Examining one's own system of values, trying to develop more consistent value patterns, and recognizing that a change in values should call for a reconsideration of conclusions reached regarding certain issues and problems

Despite limitations of space it seems desirable to comment briefly on some of the points just made. This is especially important since the outline does not adequately suggest that the pupil, in drawing conclusions about a given social problem, usually evaluates the conclusions reached by others who have studied the same problem. Unquestionably the pupil does "original" thinking on a given issue less frequently than he chooses between the conclusions of others.

In evaluating the conclusions reached by others (and in reaching his own conclusion), the pupil must identify the basic assumptions upon which a given conclusion rests. Some assumptions are probably supported by adequate data; others perhaps can be validated if additional data are found; still others might be proved invalid if further research were undertaken. Still other assumptions cannot be checked through research as, for example, definitions, value judgments, and statements of preference. If the pupil does not agree with the author's assumptions of this sort, then he cannot accept the author's conclusions. Often the pupil may have to accept or reject assumptions tentatively while he plans how to study the problem further. In so doing it is important for him to distinguish between fruitful and unfruitful lines along which to conduct this further inquiry.

In recent years many schools have placed increased emphasis on teaching pupils to practice logical reasoning and to analyze propaganda.[5] To use oral and written sources effectively the pupil should understand the "if-then" approach, the conditions under which indirect argument leads to valid conclusions and the fact that an attack on a person or institution, even though justified, does not prove lack of merit on the part of the person or institution in a given situation.

It is not enough for the pupil to recognize forms of argument which are intellectually honest; he should also be able to recognize those which are dishonest, i.e., propaganda devices. Furthermore, he will need to know that certain works, pictures, and symbols can be used to create favorable reactions; others to do the opposite. Few persons seem to realize the extent to which such procedures are used to influence the reactions of the mass of people every day in every way. Perhaps still fewer realize the extent to which they, themselves, are using such procedures to influence their fellows.

Objective 8: *Applying social facts, generalizations, and value principles to new problems.* In the foregoing section it was suggested that a pupil cannot study a social problem once, reach valid conclusions about it, and then feel that there is no reason for further thinking about that particular issue. It is important to recognize also that the knowledge and experience gained in thinking about given problems should be used by the pupil in thinking about new problems. Some of the ways in which the pupil may do this are:

[5] The common fallacies in drawing conclusions are listed and briefly described in *Teaching Critical Thinking in the Social Studies* (27: 29). For a discussion of logical thinking see Stebbing (24) and Thouless (29). See also the publications of the Institute for Propaganda Analysis (18) and Fawcett (7).

1. Detecting the relationship between known facts and new problems
2. Distinguishing between the known facts and generalizations that are relevant and those which are irrelevant to a given issue or problem
3. Avoiding undesirable forms of thinking, as, for example, mutually contradictory facts and values, and unfounded generalizations

Practicing Desirable Social Relationships

The fundamental purpose of instruction in the social studies (as it is in general education) is to effect desirable changes in the behavior patterns of young people. The Committee on the Social Studies of the Progressive Education Association held that "adolescent needs and democratic values set the task and define the role of social-studies teachers. It is . . . . [their] function . . . . to use the resources of the social sciences in meeting adolescent needs so as to develop the desirable characteristics of behavior essential to the achievement of democratic values within the realities of the changing American culture" (**23**: 23). Charles A. Beard, in his report prepared for the Commission on the Social Studies, though he did not place the same emphasis on "adolescent needs" as a crucial factor in the determination of objectives and the selection of content, nevertheless expressed much the same thought. "Our fundamental purpose . . . . is the creation of rich, many-sided personalities, equipped with practical knowledge and inspired by ideals so that they can make their way and fulfil their mission in a changing society which is part of a world complex" (**3**: 96 f.).

The knowledge pupils acquire about world affairs, the skills which enable them to increase their store of knowledge at will, their ability to think effectively about social problems and their disposition to do so—all are examples of desirable changes which may be furthered through instruction in the social studies. Although the authors of this chapter do not wish to claim all the outcomes of social education as results of instruction in the social studies, they must call attention to certain types of behavior which should result from instruction in the schools. These types of behavior may be evident in the social studies classroom, in the school as a whole, and in the community. In large part they cannot be measured by paper-and-pencil tests. For evidence of their existence the teacher must depend on observation, class discussion and conversation with pupils, analysis of written work, and so on. The following statements suggest some of the important objectives in the area of social relationships:

9. **Understanding and developing values consistent with the democratic way of life.**

10. Understanding the social implication of specific facts and types of behavior.
11. Applying democratic values consistently in judging the desirability of policies and courses of action.
12. Understanding the importance of social action to further the solution of social problems, and being willing and able to take such action.

Illustrative Evaluation Procedures

In the pages which follow, specific suggestions are made for the evaluation of the objectives listed. Exercises and procedures are presented with a minimum of comment, but in many cases published tests have been listed and helpful articles cited. An effort has been made to provide appropriate material for pupils at three levels of advancement in school work: (1) upper elementary grades, (2) junior high school, and (3) senior high school.

Objective 1. *Understanding special vocabulary.*

The Commission on the Social Studies sponsored elaborate vocabulary studies and a variety of vocabulary tests, and the extensive material on this subject in the volume by Kelley and Krey (**14**: chap. iii, appendix ii) will prove helpful to teachers in evaluating the pupil's understanding of social-science terms. Some appropriate techniques for that purpose are illustrated in a later section of this chapter (see p. 87).

Objective 2. *Understanding chronological relationships.*

The following exercise suggests a way of testing the pupil's ability to use dates to develop an understanding of the time relationships stated and implied in a given reading selection (**34**: 55 ff.).

Directions: Read this selection and whenever you come to underlined words put the date which they stand for in the margin at the right. When you see an expression beginning "for," put two dates in the margin.

Benjamin Franklin was born in Boston in 1706. His father taught him to read, and <u>when he was eight</u> he started to the Boston Grammar ______ School. This cost more than the family could afford, so Benjamin was sent to a cheaper school <u>the next year</u>. In a little while he left school ______ and was apprenticed to his brother James, who was a printer. The two brothers did not get along well and Benjamin at last decided to run away to Philadelphia. He was seventeen <u>when he arrived there</u> to try ______ his fortune. <u>The year after that</u> he was sent to London to buy a ______ printing press.

By 1732 Franklin had a print shop of his own and he began in that year to publish the famous "Poor Richard's Almanack" which ______ was printed every year for twenty-five years. He was married to Miss ______ Deborah Read two years before the first almanac was printed. The ______ year after his marriage Franklin helped to establish the first public ______ library in America. He became interested in electricity in 1746 and six years later he made his famous experiment with the kite. Just the ______ year before the kite experiment he had founded a school and a hospital. ______

Directions: Put a check in front of the event in each pair which happened first:

Franklin D. Roosevelt was elected President.
The First World War began.

Germany accepted unconditional surrender.
The Second World War came to a close.

The ability of the pupil to figure out the sequence in which a number of more or less related events happened is measured in the following exercises:

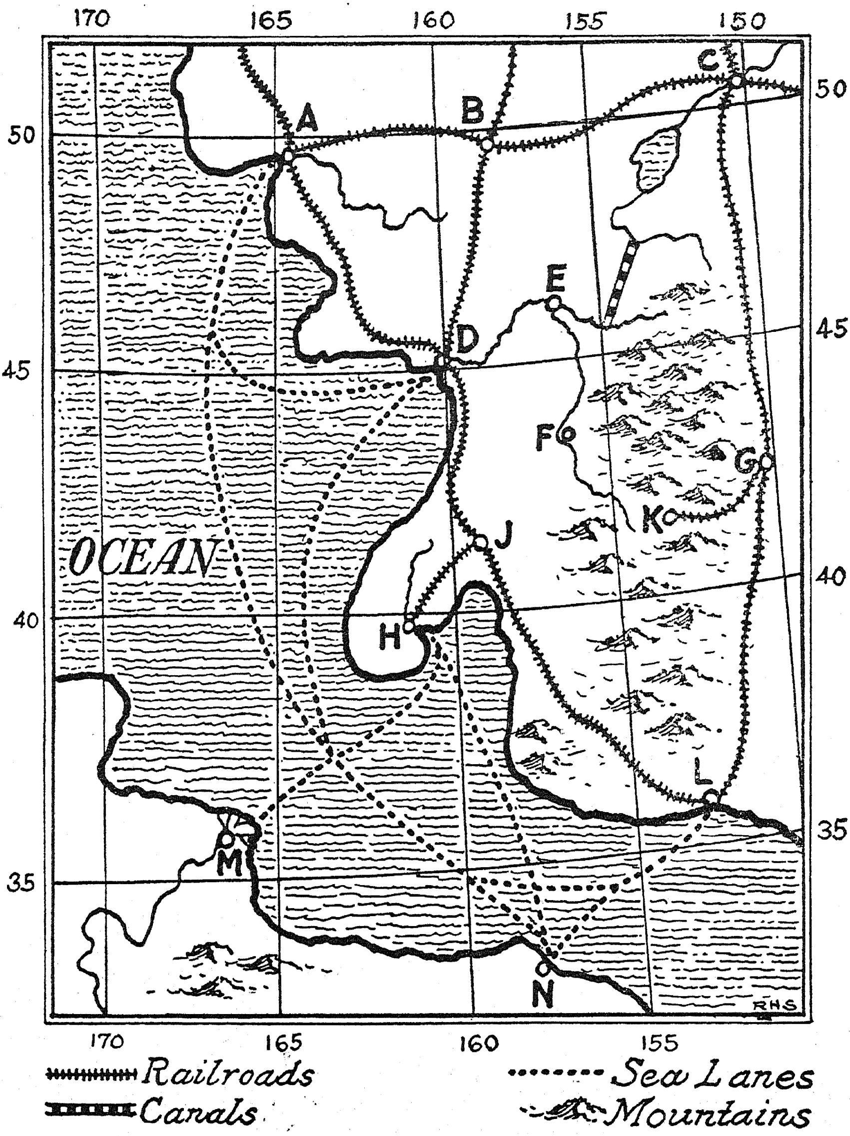
Directions: Which is the order in which the following events occurred: (1) *A C D B* (2) *A C B D* (3) *D A B C* (4) *D A C B*?

A. The steam engine was invented
B. People began to ride on trains
C. Robert Fulton made his first voyage by steamboat
D. The first telegraph message was sent

Directions: The events in the right-hand columns are in the correct order. The numbers refer to the time intervals before the first event, between successive events, and after the last event in this column. For each of the events listed in the left-hand column list the number of the time interval when it occurred.

	-1-
_____Restoration of the Stuarts	Defeat of Spanish Armada
	-2-
_____Petition of Right	Outbreak of Thirty Years' War
	-3-
_____Magellan's Expedition	Glorious Revolution
	-4-
_____Outbreak of the War of the Spanish Succession	Death of Louis XIV
_____Religious Peace of Augsburg	-5-

Objective 3. *Understanding maps.*



This map is from the New York State Regents Scholarship Examination—1944 Series, and the following multiple choice questions from that examination refer to the map.

In what direction is city *C* from city *G*? (1) due north (2) slightly west of north (3) northwest (4) slightly east of north (5) northeast

Which of these cities would receive most hours of daylight on December 15th? (1) *A* (2) *C* (3) *D* (4) *J* (5) *L*

By what route would machinery from city *C* probably be shipped most cheaply to city *N*? (1) *C-G-L-N* (2) *C-B-A-N* (3) *C-E-D-N* (4) *C-B-D-N* (5) *C-B-H-N*

If prevailing winds blow from the west, least rainfall may be expected about city: (1) *A* (2) *F* (3) *G* (4) *M* (5) *N*

What is the approximate distance from *B* to *D*? (1) 100 miles (2) 1150 miles (3) 350 miles (4) 1500 miles (5) 550 miles

What time would it be at city *A* if it were 12:00 noon at Greenwich? (1) 1:00 P.M. (2) 2:00 P.M. (3) 6:00 P.M. (4) 1:00 A.M. (5) 5:00 A.M.

One might assume the city with greatest population is: (1) *B* (2) *D* (3) *G* (4) *H* (5) *L*

Temperature changes will tend to be most rapid near: (1) *A* (2) *B* (3) *D* (4) *J* (5) *L*

What agricultural product might be produced in large quantity near city *B*? (1) wheat (2) cotton (3) sweet potatoes (4) rice (5) bananas

Of the following, the city with the lowest mean temperature is: (1) *F* (2) *G* (3) *H* (4) *J* (5) *K*

The teacher does not necessarily construct objective-type questions in order to measure the pupil's understanding of maps; nor is it necessary to draw a special map for the examination. The following free-response questions are based on the map on p. 82.

How would one be likely to travel in going from *H* to *N*? in going from *E* to *C*?

Why would direct travel between *F* and *G* be difficult?

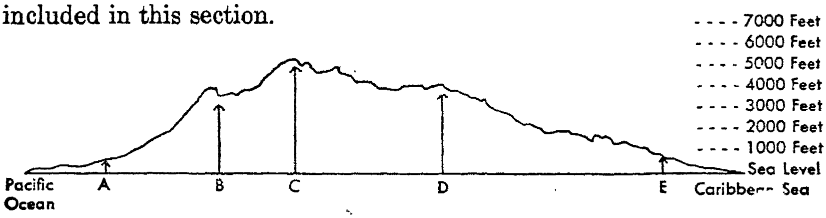
Which city is likely to have colder winters and warmer summers: *A* or *C*?

What type of transportation links *L* and *G*? *M* and *H*? *D* and *E*?

What kinds of cargo would likely be transported from *L* to *A* by water? by rail?

What crops are farmers living in the triangle bounded by *A*, *B*, and *D* likely to grow?

The questions in the following exercise refer to the elevation chart, but since they could just as well be based on a relief map, they are included in this section.



Cross Section of Central American Country
Latitude about 10° N.

Directions: This is a generalized profile of a country in Central America. At the right is a scale showing elevation. Answer the questions on the basis of the cross section and the scale, and the statement that the latitude is about 10° N. Take into account any other information you may have.

Where will coffee be grown? *A, B, C, D, E,* No place ________

Where will bananas be grown? *A, B, C, D, E,* No place ________

Where will wheat be grown? *A, B, C, D, E,* No place ________

Where will sugar cane be grown? *A, B, C, D, E,* No place ________

Which place will have the heaviest rainfall? *A, B, C, D, E?* ________

This cross section shows a place how far from the equator?
a) 10 miles *b*) 70 miles *c*) 700 miles *d*) 1000 miles ________

Directions: You may also find it possible to draw some inferences from the chart. Read the following statements. Mark each one *T* if it is *probably* true, *F* if it is *probably* false, and *X* if you *cannot tell.* Write in the blank space following each statement the reason you think each statement is probably true or probably false.

Write one
T F X

One of the main problems of this country will be to secure good transportation. ________

The density of population will be greatest between *B-C* and *C-D*. ________

If plantation agriculture exists at all, it will be found at *C*. ________

If any of these people are dairy farmers, they will be found at *A* or *E*. ________

On any given day the temperature will be higher at *C* than at *E*. ________

At *E* the difference in temperature between day and night will be greater than the difference between summer and winter. ________

Many different types of maps are included in the Map Reading section of *Test B: Work Study Skills,* one of the Iowa Every-Pupil Tests of Basic Skills for Grades V, VI, VII, and VIII: elevation, temperature, rainfall, population, mineral resources, crops, railroads, and so on. Teachers may prepare appropriate questions based either on mimeographed maps or on maps found in the textbook. Some excellent suggestions on concepts to be tested are provided by Edith Putnam Parker (**14:** chap. iv).

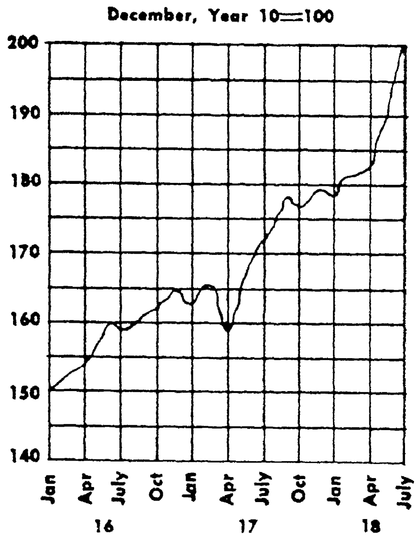
Objective 4. *Understanding graphs and tables.*

The teacher should note the sample test exercises provided by Morse and McCune (**17:** 42, 44, 45-50, 52-54, 64-66). These include

items based on bar, circle, line, and profile graphs, as well as on charts and tables. *Test B: Work Study Skills,* has a section on "Reading Graphs, Charts, and Tables."

The following test exercises are from *Test Two: Interpretation of Reading Materials in the Social Studies,* one of the Tests of General Educational Development prepared by the Examinations Staff of the United States Armed Forces Institute. Although these questions are taken from the college-level edition of the test mentioned, they are not too difficult for high-school pupils. They are included here to show the wide range of questions which may be asked—from finding an item of information to inferential thinking based on general information plus the data provided.

GENERAL RETAIL PRICE INDEX



In this (imaginary) graph, Year 16 refers to a year 6 years after Year 10, Year 17 to the next year, and so on. Assume that the period covered lies somewhere between 1900 and the present time. In answering these questions, draw inferences wherever possible on the basis of your knowledge of changes normally associated with the changes shown in the graph.

How much higher were prices in July of Year 18 than they were in January of Year 16? (1) 33% higher (2) 50% higher ((3) 66% higher (4) six times as high

Which probably decreased in the period covered by the graph? (1) unemployment (2) wages (3) dividends (4) interest rates

Which of the following people, as a class, would most probably be hurt by the

price changes in this period? (1) Those living on dividends from stocks (2) Those living on interest from bonds (3) Those who had to repay in Year 18 debts incurred in Year 10 (4) Salesmen whose income consisted largely of commissions earned by selling consumption goods

Which is shown conclusively by the graph? (1) The government tried to control inflation during this period but failed. (2) Most people were better off in Year 18 than in Year 16. (3) The price of some commodities was at least twice as high in July of Year 18, as in December of Year 10. (4) All retail prices increased between January of year 16 and July of Year 17.

Which is shown conclusively by the graph? (1) Prices were about twice as high in Year 18 as they were in most years between 10 and 18. (2) In Year 18 prices were too high. (3) The purchasing power of money decreased between Years 16 and 18. (4) Prices in Year 18 were higher than at any time between Years 10 and 16.

The following table contains information about a large northern city in the United States and about three of the many sections or communities within it.

	Section			City as a Whole
	A	B	C	
Median rental	$29.48	$27.16	$39.09	$32.05
Birth per 1,000 inhabitants	15.5	16.7	12.2	15.4
Per cent of families on relief	12.9	52.3	4.0	14.1
Infant deaths per 1,000 live births	52.3	76.0	45.3	56.7

In answering these questions, draw wherever possible on your knowledge of conditions usually associated with the conditions shown in the table.

Which of these sections of the city probably has the highest rate of juvenile delinquency? (1) Section *A* (2) Section *B* (3) Section *C* (4) Impossible to tell from the data given.

Which is probably the section that has a population largely composed of skilled and semiskilled manual workers? (1) Section *A* (2) Section *B* (3) Section *C* (4) Impossible to tell from the data given.

Which of these sections is most likely to have the largest proportion of high-school graduates among its adult population? (1) Section *A* (2) Section *B* (2) Section *C* (4) Impossible to tell from the data given.

In which of these sections did the largest proportion of people benefit directly

from New Deal policies? (1) Section *A* (2) Section *B* (3) Section *C* (4) Impossible to tell from the data given.

Which of these sections of the city is probably least crowded, i.e., has the smallest number of persons per square mile? (1) Section *A* (2) Section *B* (3) Section *C* (4) Impossible to tell from the data given.

Which of these sections probably has the highest tuberculosis rate? (1) Section *A* (2) Section *B* (3) Section *C* (4) Impossible to tell from the data given.

Which one of these statements about these sections is most probably true? (1) Section *B* is farther from the center of the city than is Section *C* (2) On the average the adults who live in Section *C* had wealthier parents than the adults who live in Section *B* (3) Affection for children is a trait more characteristic of Section *C* than of Section *B* (4) Inborn tendencies to laziness and shiftlessness are more characteristic of the people in Section *B* than of the people in Section *C*.

Objective 5. *Knowledge of important concepts, generalizations, and findings.*

The items included under this objective represent types of questions and exercises which measure reasoned understanding rather than simple recall. This statement assumes, of course, that the answers to questions have not been directly taught and that they cannot be figured out from any extraneous clues, specific determiners, and so forth, to be found in the test material.

Directions: Draw a line under the word which most nearly means the same as the first word:

Consumer: buyer, owner, user, producer
Treaty: law, truce, agreement, charter

Directions: Draw a line under the word which does *not* belong with the other words:

Ranch: plantation, fazenda, hacienda, peon
Mountain: plateau, peninsula, hill, plain

Directions: Choose the word or phrase which is most like the italicized word or phrase:

( ) The *militarism* of Assyria: (1) bravery (2) cruelty (3) love for war (4) success in ruling

( ) Babylonian records of *contracts:* (1) purchases (2) agreements (3) loans (4) payments

Directions: Choose the word or phrase which most correctly completes each statement:

( ) Men who did *not* help in building and furnishing houses were: (1) artisans (2) merchants (3) legislators (4) architects

( ) Men who did *not* help people to maintain their rights were: (1) judges (2) policemen (3) lawyers (4) inventors

Directions: Write in the parentheses the number of the best answer to each question or statement:

( ) Dispersed rural settlement is common to all but one of the following: (1) United States (2) China (3) Australia (4) Uruguay

( ) Road patterns are related to both geographical and historical conditions. A distinctly rectangular road pattern is most likely to be found in which of the following places? (1) New York (2) Virginia (3) Massachusetts (4) Iowa

( ) As the number of mechanical inventions increase and society becomes more complex: (1) Each worker does more specialized work. (2) Each person takes care directly of more of his needs. (3) People depend less on each other. (4) Each worker does a greater variety of work.

( ) Tokyo is about the same latitude as: (1) Toronto (2) Havana (3) Washington, D. C. (4) Juneau

( ) The adoption of the Constitution was generally *opposed* by (1) prosperous merchants (2) frontier farmers (3) professional men (4) holders of securities of the national government

( ) Which has been a result of this country's policy of maintaining a high protective tariff? (1) higher prices for domestic goods (2) lower prices for foreign goods (3) increased foreign trade (4) higher prices for farm products sold in foreign markets

( ) In which order did these inventions come into common use? (1) telephone, wireless, telegraph (2) telegraph, telephone, wireless (3) wireless, telephone, telegraph (4) telgraph, wireless, telephone

( ) Which is the order, from large to small, of the colonial possessions held by the following powers in 1914? (1) Great Britain, Germany, France (2) France, Great Britain, Germany (3) Great Britain, France, Germany (4) France, Germany, Great Britain

( ) The United States and the U.S.S.R. are great world powers. Which statement about the two countries is *not* true? (1) The U.S.S.R. has the larger population (2) U. S. industry has greater productive capacity (3) Both countries are leading maritime powers (4) Both countries are comparatively self-sufficient

Directions: Concentration and decentralization are two conflicting movements in American industry today. Put a *"C"* in front of conditions which are most likely to lead to concentration of industry. Put a *"D"* in front of conditions which are most likely to lead to decentralization.

( ) Nearness to raw materials ( ) cheap electric power ( ) high tax rates in city ( ) supply of labor skilled in industry

Directions: Here are four pairs of cities. One in each pair is located in Canada, the other in the United States. Explain two or more ways in which the cities in each pair are alike.

Ottawa; Washington, D. C.
Vancouver; Seattle
Toronto; Chicago
Minneapolis; Winnipeg

The teacher will find practical suggestions for building effective objective-type test items in chapter iii of *The Construction and Use of Achievement Examinations* (10). In order to see more clearly the difference between test questions which deal with isolated information and those designed to measure the understanding of important concepts and generalizations, he should examine carefully a selection of the published tests which are in general use.[6]

Objective 6. *Locating, selecting, organizing, and evaluating information.*

Defining the problem. The need to define the problem arises both in social situations which are of direct concern and in the case of issues which, though they are important, do not touch one directly. In a given class, for example, the pupils may wish to determine, "What is the best way to pass from the room in going to the next class?" The same group may also wish to study, "Why did the German generals at the close of the Second World War try to surrender to the Western Allies rather than to Russia?"

In either type of situation the problem is defined properly when it means the same to other persons as to the one who poses it. Such agreement is possible only when significant terms are defined and the scope of the problem is indicated, and this agreement often is reached through oral discussion. To evaluate understandings involved in defining the problem the teacher will need to get at the extent to which pupils (1) recognize the terms which need definition, and (2) are able to segregate the elements directly related to the problem. A written assignment may be used for that purpose. To determine how accurately pupils can define important terms one may ask for oral or written definitions, request that terms be used in original sentences, and note how accurately terms are used in the course of oral and written discussion. Certain types of vocabulary tests are also helpful. The following are examples.

Marked differences: (1) decided (2) small (3) unaccountable (4) variable[7]
What is a "ticket"? (*a*) the candidate who has been nominated (*b*) a presi-

[6] See, for example, *Test 1: Understanding of Basic Social Concepts* in Form Y-1, *Iowa Tests of Educational Development* (Grades IX-XIII, inclusive).

[7] *Iowa Every-Pupil Tests of Basic Skills* (Advanced Battery—Grades V, VI, VII, and VIII), Form M. *Test A: Silent Reading Comprehension,* p. 10.

dent before election (*c*) a list of people to be voted on (*d*) an unwritten law[8]

Using appropriate sources effectively. In determining the sources to be used in studying a given problem one should consider (1) their general dependability, (2) their appropriateness for the particular purpose, and (3) their comparative availability. To evaluate the pupil's understanding of these criteria the teacher may assign a problem which requires the use of a variety of sources and note how effectively he identifies and uses those which are appropriate, or he may provide the pupil with a list of problems and ask him to indicate useful sources in studying each of them. It is possible to use objective-type exercises, for example, to discover (1) whether the pupil can distinguish between source and secondary materials, and (2) whether he can gauge the comparative value of sources.

Directions: Put an x in front of the sources which are primary sources.
The Treaty of Versailles
Gone with the Wind by Margaret Mitchell, a book depicting conditions in the South at the time of the Civil War
The newspaper text of one of President Roosevelt's Fireside Chats, a radio broadcast
A history textbook
The Dictionary of American Biography
A photograph of the burning of the airship "Hindenburg" (17: 34).

Directions: Number sources listed in the order of value in studying about the living conditions of the ancient Romans.
An epic poem written by a Roman which mentions some family customs.
Excavations of the buried Roman city of Pompeii.
A novel about the fall of Pompeii (17: 55 f.).

The "Test on Sources of Information, Form 7.1," developed in connection with the evaluation program growing out of the Eight-Year Study, uses a similar approach except that the pupil is asked to mark *"A"* if it is a good place to go for helpful information, *"B"* if it is helpful but not a very good place to go, *"C"* if it is not worth using in studying the question.

The following test items from the Iowa Tests of Educational Development for Grades IX-XIII[9] suggest various factors to consider in choosing sources of information.

In which could you find the most recent information about Negro schools in the South? (1) a history of American education (2) an American history

[8] See 14: 189, "Test of Concepts Used in the Social Studies" by L. C. Pressey.
[9] Form Y-1, *Test 9, Use of Sources of Information,* pp. 50 ff.

textbook (3) bulletin of U. S. Office of Education (4) an encyclopedia

From which could you obtain information concerning the location of the principal oil fields of the United States? (1) Department of State (2) Department of Interior (3) Department of Education (4) Department of Agriculture

Test items of a similar sort, designed for use in Grades VI-VIII, are included in the section "Use of References" in *Test B: Work-Study Skills* of the *Iowa Every-Pupil Tests of Basic Skills.*

It is important, also, to evaluate understandings involved in using sources efficiently, e.g., how to use an index, a card catalog, and so on. *The Iowa Work-Study Skills Test* contains a section, "Part III, Use of Index," which is too long to reproduce in this chapter. This section includes an index and a series of questions. The pupil is expected to write the number of the page reference listed in the index which is likely to contain the best answer to a given question.

The following test items from *Test 9, Use of Sources of Information* in the *Iowa Tests of Educational Development* are concerned with the pupil's ability to use an alphabetical arrangement, his knowledge of the kinds of information found in various types of aids, and so on.

In which tray in the card catalog would you look to find the author card for the following reference?
Thorpe, Thomas Edward, *A Dictionary of Applied Chemistry*
(1) the *AA-Buc* tray (2) the *Buc-Cop* tray (3) the *Dod-Fin* tray
(4) the *Sui-Uni* tray

Suppose you were looking in the library for information about university education in the Middle Ages under the subject card *Middle Ages* in the card catalog, and were unable to find a suitable book. Which of these would be the best procedure for locating such a book? (1) turn to the author cards in the catalog and examine titles (2) turn to the *Reader's Guide to Periodical Literature* (3) turn to related subject cards in the card catalog, for example, *Universities* (4) examine the bibliographies of your world history textbook for suitable books

Selecting and organizing pertinent information about a given problem. Although the teacher may use a number of objective and semi-objective procedures in evaluating the pupil's understanding of how to select and organize information, the ability can best be appraised in a work situation. To get help in developing evaluation materials, the teacher should study carefully the exercises reproduced in the Thirteenth Yearbook of the National Council for the Social Studies (**27**: 57-67, 135-37).

When a problem is defined clearly it suggests the organization

which is appropriate and, therefore, what information is relevant. The ability to derive meaning from relevant information, however, depends on the pupil's understanding of the information and his skill in gauging its worth. That is, meaning is in part a matter of interpreting words and phrases correctly, but it also involves "over-all" understanding.

The Thirteenth Yearbook of the National Council for the Social Studies contains a variety of materials designed to help pupils develop criteria for judging the worth of information as evidence (27: 68-82).

The following exercise (6) deals with the incident which took place on Memorial Day in 1935 in a field near the Republic Steel Corporation in South Chicago. About 400 parading strikers clashed with about 200 police, and many strikers were killed or wounded. Edgerton includes the following in a list of those who testified or were used as testimony.

1. Police: Captain Kilroy and others
2. Marchers
3. Onlookers
4. Ralph Beck, reporter, stood near Captain Kilroy
5. Newspaper photographs and Paramount Newsreel
6. Police Investigation: Testimony of marchers and Capt. Kilroy's report
7. Coroner's inquiry into deaths
8. Medical testimony
9. George Jolly, Jr., high-school student who lived nearby
10. U. S. Senate Civil Liberties Committee—made an investigation

Before reading the fact sheet which contains excerpts from the testimony of the authorities listed, the pupils were asked to estimate their worth as "sources" of valid evidence. After reading the testimony, the pupils were asked to make a re-evaluation. The following items, among others, were to be considered:

Position makes testimony probably unreliable (or reliable).
Character of testifier makes testimony probably unreliable (or reliable).
Testimony is prejudiced by participation in dispute (or by relationship to a party in dispute).
Time at which testimony was given increases (or decreases) its reliability.
Method of obtaining evidence increases (or decreases) its reliability.
Testimony is probably colored by emotional bias.
Testimony is probably motivated by desire to serve society.
Testimony is too incomplete to be reliable.
Age and experience of testifier affects reliability of his testimony.
Social pressure probably influences testifier.
Training of witness probably adds to (or subtracts from) the reliability of testimony.

If the foregoing exercise seems complicated, the following approach, reported in the Twelfth Yearbook of the National Council for the Social Studies (**26**), may prove helpful.

A 6A class was studying the geography of Europe and the land of the Dutch people. Someone in the class said that the homes of the Dutch people who live in America are always neat and clean. The teacher asked this question, "What reasons can you give for thinking that they are always neat and clean?"

Here are some of the reasons the children gave. Read them carefully and decide which are the best and which are the poorest.
I heard someone say that they were neat and clean.
I was in one Dutch home and it was clean.
Our geography book said they were clean.
I have been in many Dutch homes and all of them were neat and clean.
I read in the story book that these houses were always neat and clean.

Objective 7. *Drawing conclusions and stating them effectively.*

It is impossible to discuss and illustrate all the types of understandings involved in drawing valid conclusions and to suggest how these may be evaluated. The teacher therefore is urged to read the Thirteenth Yearbook of the National Council for the Social Studies (**27**: 82-92, 138-49), chapter ii in *Appraising and Recording Student Progress* (**21**: 35-157), and the chapter by Marion Clark in *Tests and Measurements in the Social Sciences* (**14**: 302-39).

The following is an example of an exercise used to evaluate the ability of elementary-school pupils to draw conclusions from evidence (**14**: 306 f.). The exercise includes a picture of a horn book.

This is the only book the little children in America had in early colonial schools. It was called a horn book. On a thin piece of wood, usually about four or five inches long and two inches wide, was placed a sheet of paper a trifle smaller than the wood. The alphabet was printed at the top in large and small letters. Below were simple syllables such as *ab*, *eb*, *ib*, etc. Then came the Lord's Prayer. This printed page was covered with a thin piece of yellowish horn which showed the letters through so they could be read.

After you have looked at the picture and read the story about it carefully, place a check in the proper place after each statement.

	True	*Does Not Tell*	*False*
1. The children in colonial schools did not learn to read.			
2. The people in colonial days thought it was important for children to learn their letters.			
3. The paper used in the horn books was made in America.			

4. Many interesting stories were written for the boys and girls in the American colonies to read in school. ____________

Interpretation of data. Form 2.52, one of the tests developed by the Evaluation Staff in the Eight-Year Study of the Progressive Education Association, provides the following problem and directions (27: 145 f.):

Problem V. The table below shows the combined expenditures of all state governments in the United States for various governmental services. Amounts are in thousands of dollars.

	1910		1920		1930	
	Amount	Per Cent of Total	Amount	Per Cent of Total	Amount	Per Cent of Total
1. General government expenses	$ 43,400	11.7	$ 74,053	10.5	$ 125,000	9.1
2. Protection	19,425	5.3	32,000	4.6	72,000	5.4
3. Health	20,302	5.4	28,475	4.2	41,450	3.1
4. Recreation	2,162	0.5	4,820	0.6	9,512	0.7
5. Highways	58,300	15.9	125,400	18.2	292,441	21.3
6. Welfare	86,621	23.4	121,850	17.6	214,500	15.1
7. Education	148,265	37.8	315,122	44.3	591,240	45.3
	$378,475	100.0	$701,720	100.0	$1,346,143	100.0

For the purpose of checking the statements at the end of this problem, the data alone:

(1) are sufficient to make the statement true.
(2) are sufficient to indicate that the statement is probably true.
(3) are not sufficient to indicate whether there is any degree of truth or falsity in the statement.
(4) are sufficient to indicate that the statement is probably false.
(5) are sufficient to make the statement false.

Mark each of the following statements with the number of one of the foregoing statements which indicates your interpretation of the data in the table.

( ) In 1935 less was spent for general government expenses than for highways.
( ) The highway expenditures of New York, Ohio, and Illinois together were at least twice as large in 1930 as in 1910.
( ) The large increase in state expenditures for education between 1910 and 1930 was mainly due to the increase in high-school enrolment.
( ) In 1930 more than five times as much money was spent for highways as for health.

( ) Our state governments do not spend a large enough portion of the taxpayer's money for health.
( ) In 1929 at least 35 per cent of the total expenditures of the states was for education.
( ) The expenditures for each type of service shown in the table increased between 1910 and 1930.

The teacher does not have to construct elaborate objective-type tests to measure understandings of the type illustrated in this section. Oral discussion and written work also afford opportunities for this type of evaluation.

It is important to teach pupils not only to reach conclusions about social problems but also to evaluate the conclusions reached by others. In order to learn something about the values which underlie the pupil's reactions to social problems and his reactions to the conclusions about social problems reached by others, the teacher may wish to make use of attitudes tests, scales of beliefs, and so on. The teacher will also want to evaluate the pupil's understanding of the nature of proof, of the principles of logical reasoning, and of the devices used in propaganda.

The following is an exercise from an "Evaluation of Arguments Test" published by the Institute for Propaganda Analysis, Incorporated, in 1938:

> Mary has been making a study of different forms of government. She prepared a report which she gave before her social studies class. In conclusion she said: "There are three types of government in power today: communist, fascist, and democratic. The government of Russia is communist. The governments of Italy and Germany are controlled by Fascists. The governments of England and the United States are democratic. I have given facts to show that the governments of Russia and Italy and Germany are really unsatisfactory for the common people. If you accept these facts and this conclusion, then it follows that the democratic form of government is the only satisfactory form for the common people." Now let us assume that the facts Mary has presented concerning the three types of government in power today are accurate. Let us assume that these facts actually do show that the governments of Russia, Italy, and Germany are really unsatisfactory for the common people. Assuming these things, check the conclusion with which you agree.
>
> (1) Mary proved that a democratic government is the only satisfactory kind for the common people.
> (2) Mary did not prove that a democratic government is the only satisfactory kind for the common people.
> (3) Further information is needed before we can decide whether Mary really proved her conclusion.

Check any statements which you would use to explain or support your conclusion:

a) Mary has not considered all possibilities. Conceivably there are governments in countries she has not mentioned which are even more satisfactory than the democratic form of government.
b) The conclusion is not necessarily true, but if we accept the assumptions, then logically the conclusion does follow from these assumptions.
c) We need to know exactly what words like "communist," "fascist," and "democratic" really mean before we can decide.
d) No foreign country has a government which is as good for the common people as ours is.
e) Mary is not an authority whose arguments can be trusted in matters of foreign affairs.

Limitations of space make it impossible to illustrate procedures designed to evaluate the pupil's understanding of the principles of logical reasoning.[10] Until specific instruction is provided in this field pupils can scarcely be expected to demonstrate any great capacity for logical reasoning, and some of the published tests doubtless will prove difficult for them.

The techniques of persuasion used by propagandists are described in the publications of the Institute for Propaganda Analysis, Incorporated (18).

Objective 8. *Applying social facts, generalizations, and value principles to new problems.*

The most appropriate test of the ability to apply social facts, generalization, and value principles to new problems is actual behavior in a problem situation. Certain paper-and-pencil tests which may be used to this end are described in the Thirteenth Yearbook of the National Council for the Social Studies (27: 153-60). An example of an objective-type approach is the following exercise from one of the tests developed in connection with the Eight-year Study of the Progressive Education Association.[11]

Suppose that you are a candidate for treasurer of the Senior class. Of the other candidates there is only one, a boy, who is popular enough to be dangerous as an opponent. A few days before the election you learn from a source you can trust that this boy is an ex-convict, having served a year in the state reformatory for theft. Would you (Check one)

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[10] See *Application of Certain Principles of Logical Reasoning,* Test 5.12, Progressive Education Association, Evaluation in the Eight-Year Study. Chicago: University of Chicago; Goodwin Watson and Edward N. Glaser, *The Logical Reasoning Test.* Yonkers-on-Hudson, New York: World Book Co.

[11] *Test of Consequences.*

A. Confide in the school principal and follow his advice?
B. Tell everybody about it?
C. Say nothing to anybody about it?
D. Have a confidential conference with the boy and see if he will withdraw as candidate?

Which course (*A, B, C* or *D*) is most likely to make each of the following things happen?	Write whether desirable (*D*) or undesirable (*U*)
( ) The boy will have to leave school.	( )
( ) Your classmates will take more interest in the election	( )
( ) You will get the habit of letting older people help you with difficult problems.	( )
( ) The boy will stop trying to fool people about his record.	( )
( ) The faculty will regard you as a trustworthy student.	( )
( ) You will get the reputation of being one who carries stories.	( )

To illustrate how oral and written discussion may enable the teacher to get important information about the pupil's ability to detect the relationship between known facts and new problems, consider the following example from the field of American History.

The class was discussing the importance of maintaining so-called "full employment" after the war. One pupil brought out the fact that because of mental and physical defects some persons are unemployable. Another remarked that regional population shifts are certain to result in some unemployment; a third, that labor turn-over is not only inevitable but desirable. In this way the members of the class worked out the real meaning of the concept "full employment."

In proceeding to a consideration of why "full employment" is desirable, one pupil mentioned the fact that the country will have a national debt of 350 billion dollars and an annual interest charge of perhaps 7 billion dollars after the war. Another suggested that taxes must remain high to pay interest and to reduce the debt and to maintain an adequate defense force. He "guessed" that the federal budget just after the war would be over 20 billion dollars. Another pupil recalled that during the great depression the national income fell below 60 billion dollars and that one-fifth of the workers were unemployed and, therefore, unable to pay taxes and to support themselves.

During the discussion one pupil expressed approval of "full employment" by saying that he felt "most workers didn't know how to use their spare time to advantage," and that he was "glad they were now going to have to work a much longer day." One of the boys blurted out that he opposed "full employment" because he believed that "a woman's place is in the home."

The teacher who closely follows class discussion and analyzes the written work submitted by pupils is sure to learn a great deal not only about what pupils know but also about how effectively they think and what values they cherish.

Objectives 9 to 12. *Practicing desirable social relationships.*

Through observation, the teacher may form an impression of the professed attitudes and the actual behavior of his pupils. The observation may be general or limited to a consideration of behavior reflecting given values; it may be comparatively undirected or focused on specific items included in a rating scale. In any event, the validity of the observational record depends on such factors as (1) the accuracy of the observation or of the observer, (2) the accuracy of the observer in reporting what he saw and heard, (3) the observer's ability to interpret correctly what he saw and heard, and (4) the representativeness of the observed behavior.

Anecdotal behavior records. The following is an illustrative entry in an anecdotal journal.

October 10. John lingered after school today and in our conversation it came out that he can see no reason for learning about the people of Mexico. He said, "My father had Mexicans working in the orchard last summer. He says they're no good—lazy and dirty. My mother says she won't have them around this year if all the fruit rots on the trees!"

November 15. In the discussion of transportation problems in Peru (following the showing of a film), John remarked, "Well, why don't they get busy and build some railroads? These mountains aren't worse than the Rockies, and we have trains running over them."[12]

Rating scales. If the teacher is concerned with observing the specific reactions of pupils in a given situation—that is, reactions which reveal the presence or absence of socially significant understandings—he may save time and make more accurate observations if he first constructs a simple scale. He must, however, exercise considerable care in constructing such scales, for the situations selected must be such as to afford opportunity for understandings to operate. Moreover, he must exercise corresponding care in recording and interpreting his observations, for he must not be distracted from his search for evidence of understanding by extraneous factors or considerations.

In a fifth-grade class where committee and group work is in progress, the teacher might wish to discover whether his pupils are (to some extent at least as the result of understandings) making sound social adjustments. For this purpose he might make observations of the following types of behavior:

5. Heads a group easily without nervousness or aggression
4. Heads a group, but occasionally has difficulty
3. Works with other individuals

[12] The following references suggest how to interpret anecdotal records: 12; 20; 30.

2. Works alone
1. Works neither with group nor alone; drifts

October 1	5	4	3	2	1
John	x				
Mary			x		
Lois			x		
Harry		x			
George					x

Notes

Mary and Lois talked together in their group, and went to library to search for more material.

George moved from one group to another. Stood before aquarium for five minutes.

The following are some commercial rating scales: Haggerty-Olson-Wickman, *Behavior Rating Schedule.* Yonkers, New York: World Book Co.; Eugene R. Smith, *Behavior Description Form.* Chestnut Hill, Massachusetts: Beaver Country Day School; *Winnetka Scale for Rating School Behavior and Attitudes.* Winnetka, Illinois: Winnetka Educational Press.

The following example is from a "rôle taking" scale (**25**: 50 ff.), i.e., a scale developed to help teachers measure the extent to which pupils can put themselves in the position of another person. It was used at a sixth-grade level. This scale is presented here, as are also the similar scales which follow, because the behavior of pupils in the situations described may shed light on the degree to which they are "practicing desirable social relationships" (Objectives 9 to 12). If the scales themselves yield ambiguous evidence with respect to the possession of the essential understandings, they can at least provide the basis for more intensive study of individuals. Personal conferences relating to the scale records can yield a good deal of evidence in the matter of social understandings.

In forming two teams on the playground at noon, several children are overlooked by the captains choosing sides. Would the child being rated note the omission and call attention to these children? (Rate according to following scale.)

Very likely	Likely	Uncertain	Unlikely	Very unlikely
5	4	3	2	1

The following examples are taken from scales designed to measure phases of democratic behavior in the classroom: own rights, others' rights, share in decisions, and independence of teacher (**25**: 62 ff.)

The children are supposed to wait their turn in line to get the paints they need. The teacher is busy in another part of the room when some of the children step ahead of this child in the line. Would the child being rated protest?

Very likely	Likely	Uncertain	Unlikely	Very unlikely
5	4	3	2	1

Three groups have been working on plays. The children find that only one play can be given in the school assembly. Would the child being rated suggest that the teacher decide which play should be given?

Very likely	Likely	Uncertain	Unlikely	Very unlikely
5	4	3	2	1

The following problem situations were included in a rating scale designed to measure certain aspects of school citizenship: tolerance, school rules, school responsibility, courtesy, co-operation and social participation (**19**: 131 ff.).

A minority of the pupils have taken an unpopular position on a debatable question. They insist on stating their arguments. Would this pupil help create a situation in which they might express their opinions?

Very likely	Likely	Uncertain	Unlikely	Very unlikely
5	4	3	2	1

A visitor is walking down the hall, apparently looking for a certain classroom or teacher. He walks up to a group of pupils who have a chance to note that he needs direction. Would this pupil be likely to ask the visitor if he might be of service to him?

Very likely	Likely	Uncertain	Unlikely	Very unlikely
5	4	3	2	1

Tests of attitudes. Although many studies have revealed a low correlation between professed attitudes and actual behavior, tests of attitudes have value in that they reveal what pupils claim that they approve or reject. The use of attitudes tests serves the further purpose of causing pupils to recognize issues, to discover inconsistencies in their value patterns, and to reflect on the differences between what they accept in theory and what they actually do.

The simplest form of attitudes test is a list of stimulus words. The pupil is asked to underline each word which he does not like or which bothers or disturbs him.

Sunday School	Communist
Germany	War
Cigarette	Soldier
Republican	Invasion
Alcohol	Strike
Democrat	Peace
Russia	Mob
Capitalist	Negro
Labor union	Black market
Socialist	O.P.A.

The following are some uses which may be made of free-response type attitudes tests (16; 5).

What are your feelings about war? (Use desired stimulus words, as for example, Japan, Russia, Negroes, and so on.) Write down all the things you feel about war, and put down your reasons for feeling that way.

In analyzing the answers to such questions, the teacher (1) makes a count of adjectives and (2) notes attitudinal words expressing love, hate, fear, and so on. He may also construct attitudes scales based on the free responses.

On attitudes scales used at the upper-grade levels the pupil often is asked to check for each item or statement the one of five responses which states most accurately how he himself feels about it: "Strongly agree," "Agree," "Undecided," "Disagree," "Strongly disagree."[13]

No group should be ridiculed because of its religious practices. (Tolerance)
A school strike would be a good way to protest against an undesirable school regulation. (School rules)
A student should pick up another student's waste paper without being asked by the teacher. (School responsibility)
No one should be expected to pay attention in class to anything which is uninteresting. (Courtesy)
A difficult task should be worked out by a group of students. (Co-operation)
The chance to attend a school party thrills me. (Social participation)

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CHAPTER VI

THE MEASUREMENT OF UNDERSTANDING IN SCIENCE

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The development of understandings in the context of the material and method of science is one of the most important objectives of science instruction. Although the emphasis in this chapter is placed on understandings from science instruction, other important outcomes such as desirable attitudes and interests are also assumed to be necesary if science instruction is to result in happiness for the individual as a member of a democratic society.

A useful definition of understanding as an outcome of science instruction is given in the report of the Committee on the Function of Science in General Education (6): "The term 'understanding' is used to denote a major conception so grasped as to illuminate its connections with related conceptions and to result in significant changes in the individual's behavior."

A distinction between the term "understanding" as it has been already defined and the term "generalization" will probably serve to sharpen further the concept of understanding as it is used in this chapter. A person's actions and his behavior may be based on an understanding which is completely valid for his particular level of development. He may not, however, have verbalized the understanding which is the basis of his action or behavior. On the other hand, another person may be able to verbalize the same understanding with-

out recognizing its application to problems and experiences which are constantly occurring about him.

The term "generalization" as it is used subsequently in this chapter means a purely verbal statement of a *potential understanding*. An illustration of this distinction is the following generalization: "The production of the various kinds of goods needed by modern society depends upon the use and control of a wide variety of materials." The person who possesses an understanding of this generalization would be able to document it with certain relevant facts and information; he would also be able to use the generalization in making predictions about the future and in giving explanations of trends and other specific illustrations of the generalization as they occur in his everyday life. According to this distinction, therefore, the actual verbal restatement of a generalization is less important as an outcome of science instruction than is the ability to use such generalizations.

Potential understandings (generalizations) may be classified into two broad categories: generalizations concerning *facts* about matter, energy, and organisms which pertain to problems of living; generalizations concerning the *methods* of science which also pertain to problems of living. An example of a broad generalization of the factual type is: "Diet has important effects on growth, disposition, complexion, and disease." An understanding of this statement implies an adequate background of information, attitudes, and habits. Two examples of generalizations concerning the *method* of science are: (1) "The method of varying single factors (as in the diet of animals) makes it possible to discover the effects of each factor," and (2) "The technique of evaluating authorities is an indispensable part of the layman's equipment in selecting the more reliable from a mass of information and misinformation with which he is presented."

Science Understandings as Outcomes of Instruction

For the purposes of evaluation, the definition of understanding must be stated more explicitly with regard to expected outcomes. Such definitions are concerned with two major aspects of behavior: the nature of the behavior expected if understanding exists; and the context in which the specific behavior is expressed.

Nature of the Expected Behavior

Factual Understandings.—An understanding of factual generalizations may be defined[1] with respect to such activities as:

[1] The definitions which follow will be restated in more specific terms at later points, when each is considered from the viewpoint of evaluation devices.

FU-a. Giving specific illustrations or examples of factual generalizations and concepts of science.

FU-b. Using factual generalizations for the purpose of making predictions in new problems.

FU-c. Using factual generalizations for the purpose of explaining a given phenomenon, or for the purpose of judging the validity of a given prediction, conclusion, course of action, or practice.

FU-d. Using factual generalizations in formulating hypotheses.

FU-e. Using factual generalizations as one basis for judging the validity of sources of information.

Method Understandings.—An understanding of generalizations concerning the method employed in scientific analysis and problem solving may be defined with respect to such procedures as:

MU-a. Making proper qualifications when interpreting data. This general characteristic of behavior evidencing understanding of method in science involves the following procedures: cautious extrapolation and interpolation, recognition of the adequacy or inadequacy of a sample of data, care in reasoning by analogy, avoidance of the practice of imputing purpose or a predetermined plan on the basis of data, and the establishment of relations between data and value judgments.

MU-b. Identifying necessary and unstated assumptions involved in a conclusion, prediction, course of action, or practice.

MU-c. Recognizing and using defensible arguments or reasons when justifying a prediction, conclusion, course of action, or practice.

MU-d. Identifying valid cause-and-effect relationships when interpreting a given phenomenon.

Context in Which Expected Behavior Is Revealed

The second major factor involved in the definition of understandings as desired outcomes of instruction in science is the context in which both factual and method understandings should be revealed. The conclusions of many educational organizations and committees indicate that such understandings should be expressed in the context of the most common activities of the individual.[2] An authoritative list of such needs is presented as a report of the National Committee on Science Teaching (5). This report comprises a check list of functional outcomes designed to meet needs in the following areas at the preschool, primary, intermediate, junior high, senior high, and junior

[2] For a more detailed analysis of needs, the following references are suggested: 3, 5, 6.

college levels: health, safety, recreation, maturing interpersonal relations, responsibility in socio-economic activities, consumership, maturing philosophy of life, work, and conservation.

The two major factors involved in the definition of desirable outcomes in science may be summarized in the following diagram:

Outcomes Representing Science Understandings

A. Behavior desired	+	B. Context in which desired behavior should be demonstrated
Factual Understandings:		
FU-a. Giving illustrations of factual generalizations.		
FU-b. Using factual generalizations to predict.		Health
FU-c. Using factual generalizations to explain a phenomenon, to judge the validity of a prediction, course of action, etc.		Safety
		Recreation
FU-d. Using factual generalizations to formulate hypotheses.		Maturing interpersonal relations
FU-e. Using factual generalizations to judge the validity of sources of information.	+	Responsibility in socio-economic activities
		Consumership
Method Understandings:		
MU-a. Making proper qualifications when interpreting data.		Maturing philosophy of life
MU-b. Identifying unstated assumptions in conclusions.		Work
MU-c. Recognizing and using defensible argument when justifying a conclusion.		Conservation
MU-d. Identifying valid cause-and-effect relationships.		

Any technique employed for the purpose of appraising the degree of understanding should take account of both factors (behavior expected and context). According to the summary above the most desirable science understandings are represented by the behavior defined in the first column and demonstrated in the context of the various activities of living as represented in the second column. The first two illustrations given in the following section of this chapter indicate how the behavior and context are taken into account.

Illustrations of Techniques for Measuring Understandings

The techniques which follow are classified broadly into two groups in which emphasis is placed on the expected behavior:

FU. Illustrations of techniques for measuring *factual understandings.*
MU. Illustrations of techniques for measuring *method understandings.*

The suggestions, offered in conformity with the ideas expressed in Section I of this yearbook, represent possible devices for obtaining evidence concerning many of the elusive but important outcomes related to understanding. No consideration is given to questions of reliability. A maximum effort is made, however, to present illustrations of the kinds of behavior described above.

Factual Understandings (*FU*)

FU-a. Giving specific illustrations or examples of generalizations.—Possession of this understatnding is attested by a person's ability to illustrate a major generalization with concrete examples. Such examples may be specific facts or minor principles which have constituted a part of the learning experience. In addition, they may be new illustrations in the sense that an understanding is enhanced by a recognition of specific instances not formally dealt with at the time of learning.

Exercises 1 to 3 show how the ability to illustrate a generalization may be detected. One of the illustrations deals mainly with materials pertaining to public health, and another primarily with generalizations involving a world picture.

Exercise 1.[3]

"Are you learning to recognize examples of generalizations?" From your work in this course you have had the opportunity to summarize many of your experiences in the form of generalizations. Four of these generalizations are listed below as A, B, C and D.

[3] H. G. McMullen, "A Unit on Public Health," (6).

A. Public hygiene is mainly useful in prohibiting acute infectious diseases.
B. Difficulties created by the size of large cities are often met by applied science.
C. Institutions and patterns tend to remain fixed as the conditions which created them change.
D. Individual hygiene is mainly concerned with the prevention of chronic diseases.

The following statements may or may not represent illustrations of these generalizations. In the appropriate columns to the left check those which you believe are illustrations of these generalizations.

Statements

A B C D

__ __ __ __ *a*) Smallpox is now a relatively rare disease.
__ __ __ __ *b*) In present-day practice, most people are buried in cemeteries.
__ __ __ __ *c*) Many people ride on subways.
__ __ __ __ *d*) Children work in factories.
__ __ __ __ *e*) Millions of dollars are spent each year for patent medicines.
__ __ __ __ *f*) Very many cases of syphilis are present in the United States.
__ __ __ __ *g*) The sick child is sent home from school.
__ __ __ __ *h*) Large milk trucks and trailers are often observed on the road.
__ __ __ __ *i*) A person doesn't worry about the water he drinks from a faucet.
__ __ __ __ *j*) Most people go to a family physician for all their ailments.
__ __ __ __ *k*) Many cases of death for women result from abortion at the hands of quacks.
__ __ __ __ *l*) Evolution is not taught in many schools.

Exercise 2.

Which of these statements illustrate the principle: "The environment acts on organisms, and organisms act on their environment"?

1. Air is not one of the three great environments.
2. Oxygen unites with food and releases energy in living things.
3. Some organisms can live without "free" oxygen.
4. There are many different kinds of ticks.
5. Parasites often make their hosts ill or even kill them.
8. An environment includes such factors as light, heat, food, air, and water.
7. Grasshoppers require open, sunny places and food for their active bodies.
8. Land, fresh water, and salt water are the three great environments.

Exercise 3.[4]

"Understanding of Principles." In the following exercise a number of statements are given. At the top of the list of statements you will find two

[4] Materials prepared by the Cooperative Study in General Education, American Council on Education, University of Chicago, 1939.

principles or generalizations of which the statements below may or may not be illustrations.

You are to decide which of the statements represent illustrations of the stated generalizations.

If you believe a statement represents an illustration of generalization (A), check the space in the *first* column corresponding to the number of the statement. If you believe the statement represents an illustration of generalization (B), check the space in the *second* column. If you believe a statement is not an illustration of either generalization (A) or (B), check the space in the *third* column. [In case you believe a statement represents both principles (A) and (B), check the spaces in both the *first* and the *second* columns.]

Principle or Generalization

(A) Every particle in the universe attracts every other particle with a force proportional to the product of the masses divided by the square of the distance.

(B) A nearby body exhibits an apparent motion with respect to a more distant object as the position of the observer changes.

Statements

Generalization
A B Neither

__ __ ___ 1. The distance to the nearer stars can be measured.
__ __ ___ 2. The earth moves through space unaffected by other planets.
__ __ ___ 3. The moon has little or no atmosphere.
__ __ ___ 4. Mercury may appear as a morning or as an evening star.
__ __ ___ 5. The mean density of the earth as a whole is approximately six times that of water.
__ __ ___ 6. The lengths of light waves emitted by a star moving toward the earth appear to be shorter than those emitted by the same star if it is moving away from the earth.
__ __ ___ 7. It has been proved that the earth moves around the sun.
__ __ ___ 8. The diameter of the earth's orbit is sometimes used as a "base line" in astronomical calculations.

FU-b. Using generalizations for the purpose of making predictions in new problems.—Understanding factual generalizations means that the student should be able to employ such generalizations in a variety of ways. He should be able to make predictions of an exact type such as those which frequently occur in problems of physical science as well as those of a more qualitative type such as the *more than, less than,* or *same as* type. He should also be able to make predictions concerning how a process or device would operate, or what should be done in a given situation.

The following examples indicate how the behavior described above has been evaluated by measuring devices.

Exercise 4.[5]

"Applying Principles." John prepared an aquarium as follows. He carefully cleaned a ten-gallon glass tank with salt solution and put in a few inches of fine washed sand. He rooted several stalks of weed (*elodea*) taken from a pool and then filled the aquarium with tap water. After waiting a week, he stocked the aquarium with ten one-inch goldfish and three snails. The aquarium was then left in a corner of the room. After a month the water had not become foul and the plants and animals were in good condition. Without moving the aquarium he sealed a glass top on it.

What prediction, if any, can be made concerning the condition of the aquarium after a period of several months?

If you believe a definite prediction can be made, make it and then give your reasons.

If you are unable to make a prediction for *any* reason, indicate *why* you are unable to make a prediction (give your reasons).

An analysis of the student's reasons will reveal the extent to which he explains his prediction in terms of valid biological principles or generalizations. Frequently the unacceptable reasons given by students fall into definite types. Among the most frequent types are: assuming the conclusion, using incorrect analogy, citing incorrect authority, and resorting to teleological reasoning.[6] The alert instructor can quickly detect such erroneous reasoning and show its fallacy.

Exercises like the one described above may be developed in such a way that the situation is inadequately described. The student is expected in such exercises to indicate that a prediction is not possible and also to indicate *why* a prediction is not possible (**5**:81).

Essentially the same behavior as that requested in the preceding exercise is involved in the following item in which the response is of the short answer (objective) type.

Exercise 5.

John prepared an aquarium as follows. He carefully cleaned a ten-gallon glass tank with salt solution and put in a few inches of fine washed sand. He

[5] Adapted from Test 1.3B, "Application of Principles in Science," Progressive Education Association, Evaluation in the Eight-Year Study, University of Chicago, 1940.

[6] For a more detailed analysis of desirable and undesirable behaviors involved in the application of principles as well as further testing examples the reader should refer to 1: 247; 6: 413-18; 7: 81-111.

rooted several stalks of weed (*elodea*) taken from a pond and then filled the aquarium with tap water. After waiting a week, he stocked the aquarium with ten one-inch goldfish and three snails. The aquarium was then left in a corner of the room. After a month the water had not become foul and the plants and animals were in good condition. Without moving the aquarium he sealed a glass top on it. <u>The sealed aquarium will probably remain in good condition for several months. ( )</u>

Directions: If you are uncertain about the truth or falsity of the underlined conclusion either because the problem is inadequately stated or for any other reason, indicate your uncertainty by placing the letter "U" immediately after the underlined conclusion.

If you believe that the underlined conclusion is quite likely to be true, place a "T" immediately after the underlined conclusion.

If you disagree with the underlined conclusion, place a "D" after the underlined conclusion.

Reasons: If you were uncertain ("U") about the conclusion, select from the first 10 reasons given below all those which help you explain why you were uncertain. Indicate each reason so chosen by placing a check mark in the parentheses in front of the reason.

If you believe the conclusion to be true ("T") or if you disagree ("D") with the conclusion, select from reasons No. 11 through No. 24 all those which help you to explain your decision thoroughly. Indicate which reasons you choose by placing a check in front of each.

Reasons to be used if you are *uncertain:*

( ) 1. Many people who keep fish in bowls change the water frequently.
( ) 2. It is difficult to know what is meant by the term "good condition."
( ) 3. Not all of the aquaria I have seen were sealed.
( ) 4. The amount of exposed water surface is an important factor in keeping a sufficient amount of oxygen in the water to support life.
( ) 5. Some water plants produce more oxygen than others.
( ) 6. Two few fish in a large aquarium will affect the condition of the plants in the aquarium.
( ) 7. The amount of direct sunlight the aquarium receives is an important factor in determining whether or not the aquarium will remain in good condition.
( ) 8. Some fungi harmful to aquatic life develop more rapidly when the oxygen supply is cut off.
( ) 9. I do not know how sealing an aquarium would affect the plants and animals in it.
( ) 10. It is important to know the amount of harmful chemicals, such as chlorine, used in the tap water.

Reasons to be used if you *agree* or *disagree:*

( ) 11. The balance between plants and animals is attained in an aquarium when each supplies the needs of the other.

( ) 12. The water plants and micro-organisms would not grow rapidly enough to supply sufficient food for the fish.

( ) 13. Aquaria in biology classrooms are often kept in balance for several months even though sealed.

( ) 14. Plants in a sealed aquarium continue to manufacture food that is utilized in their growth, and they in turn serve as food for animals.

( ) 15. Just as organisms live at great depths in the ocean where there is little oxygen, so can fish live in a sealed aquarium.

( ) 16. Clerks in pet shops say that a balanced aquarium can be maintained for a long time even if sealed.

( ) 17. In a sealed aquarium, sufficient oxygen cannot be absorbed from the enclosed air to supplement the oxygen given off by the plants.

( ) 18. A balance in an aquarium tends to be maintained as long as one of the interdependent factors does not become predominant.

( ) 19. It is possible to maintain a balance in a sealed aquarium for several months.

( ) 20. If undisturbed, nature will strike a balance between plants and animals in a region.

( ) 21. Just as one does not need to feed fish in a pond, so one does not need to supply food in an aquarium containing an abundance of plant and animal life.

( ) 22. Anyone who has studied biology should know that a sealed aquarium can be maintained in balance for several years if undisturbed.

( ) 23. The snails in an aquarium can devour the solid waste material and excess algae in the water.

( ) 24. The animals in the sealed aquarium can breathe dissolved oxygen supplied by the plants.

In this exercise an effort has been made to state a situation with sufficient completeness that a definite conclusion is possible. The student is, therefore, expected to recognize that probably all of the relevant factors are taken into account. Some students, however, either because of overcautiousness or because they do not possess an adequate understanding of facts, will take advantage of any opportunity to avoid making a decision. Thus, in giving an apparently plausible reason for being uncertain, a student may say, "Some water plants produce more oxygen than others." Although this statement is true, other factors are sufficiently well stated in the exercise for the purpose of reaching a definite conclusion.

A definite plan has been followed in preparing reasons to be used for agreeing with or disagreeing with the conclusion. Reasons 11, 14, 18, 23, and 24 represent valid statements of biological principles used to justify the correct judgment concerning the conclusion, namely, that it is probably true. In addition, reasons 13 and 21 represent auxiliary

evidence which a student might rightly submit for the purpose of justifying a correct prediction. Reasons 15, 16, 19, 20, and 22, although they apparently support the correct conclusion, represent incorrect types of reasoning, namely, poor analogy, poor authority, assuming the conclusion, assuming that everything works according to a predetermined plan, and the use of ridicule.

In this type of measurement exercise it is thus possible not only to have students make a prediction, but also to have them analyze the kind of reasoning which they employ when justifying their prediction.

Certain revealing information concerning the student can be obtained by means of an appropriate summary of his responses to a series of test items like the one described. A suggested summary together with interpretations may be found in *Appraising and Recording Student Progress* (7: chap. ii). Briefly, such a summary consists of right and wrong predictions and reasons, an analysis of wrong responses, and indices of the extent to which the reasons consistently or logically support the suggested predictions.

FU-c. Using generalizations for the purpose of explaining a correct conclusion or prediction.—The following exercise represents one effort to determine how a student would justify a conclusion which is assumed to be correct.

Exercise 6.[7]

The italicized statement at the end of the problem is assumed to be a correct answer. You are to *explain* the italicized conclusion by selecting statements from the list following the problem." [The student checks the explanations.]

"If a person is planning to bathe in the sun, at what time of day is he most likely to receive a severe sunburn? *He is most likely to receive a severe sunburn in the middle of the day* (11 A.M. to 1 P.M.) because:

( ) We are slightly closer to the sun at noon than in the morning or afternoon.

( ) The noon sun will produce more "burn" than the morning or afternoon sun.

( ) When the sun's rays fall directly (straight down) on a surface, more energy is received by that surface than when the rays fall obliquely on the surface.

( ) When the sun's rays fall directly (straight down) on a surface, less sunshine is reflected from the surface than when the sun's rays fall obliquely on that surface.

[7]Taken from Inventory 1.5, Analyzing Health Problems; Cooperative Study in General Education. American Council on Education, University of Chicago, 1941.

( ) When the sun is directly overhead the sun's rays pass through less absorbing atmosphere than when the sun is lower in the sky.
( ) Just as a bullet shot straight into a block of wood penetrates farther into the wood, so will the direct rays at noon penetrate more deeply into the skin.
( ) The air is usually warmer at noon than at other times of the day.
( ) The ultraviolet of the sunlight is mainly responsible for sunburn.

A procedure which has been used with marked success in measuring understanding in science is very similar to tests of reading comprehension. Most of the questions based on the following passage test the student's ability to use scientific information for the purpose of explaining a given phenomenon (FU-*c*). Some of the questions test the student's ability to make proper qualifications when interpreting data and identifying valid cause-and-effect relationships (MU-*a* and MU-*d*). In actual practice it may not be necessary for a teacher to classify all questions used as fitting under this or that category. The following device illustrates well the advantages of the method described.

Exercise 7.

Read the following article and then answer the questions by placing an "X" in the parentheses in front of what you consider to be the best answer for each question. You may look at the article as often as you care to.

Two boys, Bill and Tom, were playing with a small horseshoe magnet when one of them suggested that they try to make a compass.

Tom said, "I'll get the stuff if you tell me what to get."

Bill said that they needed a needle, a cork, and a pan of water. Tom got the needle, and Bill started stroking it on the magnet. He stroked in only one direction.

"Why do you rub it that way?" asked Tom.

"The needle won't be a good magnet unless you rub it this way," was Bill's reply.

Tom had not been able to find a pan, but Bill said that a big bucket would be all right. Bill thrust the needle through the top of a flat cork and carefully placed it on the water in the iron bucket Tom brought. The cork immediately started toward one side of the bucket. When the needle reached the side, it seemed to stick there. Bill picked up the cork with the needle in it and put it in the center of the bucket again, but once more it went to the side and stuck. This time it did not stick in the same place as on the first trial.

Finally Bill said, "I don't know what's wrong. It certainly isn't acting like a compass."

"Perhaps you should have rubbed the needle both ways on the magnet," offered Tom. "Let's try that."

"O.K.," said Bill, and he started stroking the needle on the magnet again.

1. Do you think the needle worked as a compass after the boys had stroked both ways on the magnet? ( ) Yes ( ) No ( ) Cannot be sure.
2. What part of Bill's plan for making a compass was most likely to cause trouble? ( ) Using a cork. ( ) Using a pan or bucket which was made of iron. ( ) Using a needle.
3. Which of these things was probably responsible for the boys' failure? ( ) Stroking the needle only one way. ( ) Using a cork to float the needle. ( ) Using a bucket made of iron. ( ) Using a bucket that was permanently magnetized.
4. Do you think the needle was magnetized? ( ) Yes ( ) No ( ) The article did not give any clue.
5. The usual compass has a magnetized needle which is balanced on a pivot, so that the ends are free to swing in any direction. What in the boys' plan took the place of the pivot? ( ) The water. ( ) The needle. ( ) The bucket.
6. Why might stroking the needle only one way make it a stronger magnet? ( ) It drives the magnetism deeper. ( ) It arranges the particles that make the needle a magnet. ( ) It gives every part of the needle a chance to be touched the same amount of time.
7. Which of these changes in the boys' plan would be most likely to bring success? ( ) Using a nail instead of a needle. ( ) Stroking or rubbing in all directions. ( ) Using oil instead of water. ( ) Using a glass bowl instead of the iron bucket.
8. Why do you think the needle moved toward the side of the bucket? ( ) The needle, being a magnet, exerted a pull on the iron in the bucket. ( ) The needle being free to move started moving toward the north magnetic pole. ( ) The boys probably left their magnet on that side of the bucket.
9. If the compass the boys made had worked, would the needle have pointed directly north and south? ( ) Yes ( ) No ( ) The article does not give enough information to answer.

It should be noted that the various questions call for different degrees or levels of understanding and that each question is independent of the others. Thus, an indication of the student's degree of understanding can be obtained without using the unnatural and often complicated procedure of having him tell why one response instead of another is to be chosen.

D. K. Curtis has developed tests designed to measure the ability to apply scientific generalizations at the intermediate-grade level.

The following sample test items are taken from a test included in Curtis'[8] master's thesis.

Exercise 8.

The things we have read and talked about and the things we have seen on our trips should help us understand things we see. We should know more about the "why" of the things we see everyday. You should be able to give the correct "why" for each statement written on these pages. I have written four "whys" below each statement. See if you can find the correct one for each statement. Place an *X* in front of the "why" that is correct.

The streams cut deep into the land in our community causing the land to be very hilly. Why?

a) We have so much more rain than other places in the country and these rapidly moving streams carry more soil away.
b) The rock under the soil in our community is sedimentary rock which is rather easily cut through by the streams.
c) The rainfall of this community is so small that there isn't enough vegetation to keep the soil from washing away.
d) The winters are not cold enough to keep the ground frozen and this permits streams to wash the soil away all year round.

Most of the water that enters the coal mines west of Kirksville runs down the shaft. Why?
a) The ground water moves along layers of shale and into the mine shaft.
b) The sides of the mine shaft are sprayed with water to prevent the dirt from caving into the mine. Much of this water runs into the mine.
c) The water runs down the surface of the hills and into the mine shaft.
d) Water is pumped down the shaft and into the mine to settle the coal dust.

Many times we see trees only along the banks of streams. Why?
a) Trees grow faster along streams and provide the farmer with more fuel in less time.
b) The trees along the streams prevent the soil from washing away so easily.
c) The trees along the streams provide shade for the farmer's cattle.
d) The trees along the stream prevent the wind from blowing the farmer's corn down so badly in nearby fields.

When the farmer plants corn on hilly land the crop is usually better on the level land at the top of the hill than on the side of the hill. Why?
a) The level land at the top of the hill receives more sunshine than the side of the hill.
b) Water has washed more good soil from the side of the hill than from the level land at the top of the hill.

[8] D. K. Curtis. "The Geological Interpretation of Geography in the Intermediate Grades of the Elementary School." Master of Arts dissertation, State University of Iowa, 1936.

c) More of the corn is blown down on the side of the hill than on the level land at the top of the hill.

d) The crops have taken more fertility from the land on the side of the hill than from the land at the top of the hill.

FU-d. Using factual generalizations in the formulation of hypotheses.—Factual generalizations are frequently involved in the formulation of tentative hypotheses concerning the solution of a problem. Such problems differ somewhat from the more straight-forward application of principles in problems such as those indicated above in that they are usually more complex. They frequently involve what seems to be an inconsistency and, most important, they offer the possibility of several alternative solutions.

The following exercises were taken from a trial test prepared by the Evaluation Staff of the Eight-Year Study.

Exercise 9.

The formulation of reasonable hypotheses. A housing concern has made some experiments on methods of heating houses. A room was constructed with walls that could be heated or refrigerated at the same time that air of any temperature was being circulated through the room. Several individuals were asked to record their sensations as the conditions were varied as follows:

Trial	*Wall Temperature*	*Air Temperature*	*Sensations*
1	85°	85°	Uncomfortably hot
2	85°	50°	Uncomfortably hot
3	70°	85°	Comfortable
4	70°	70°	Comfortable
5	70°	50°	Comfortable
6	50°	50°	Very cold
7	50°	70°	Uncomfortably cold
8	50°	85°	Cold

How can you explain the sensation of "coldness" by a person in a room where the air temperature is 85° and the wall temperature is 50° (all temperatures Fahrenheit)? Consider the following questions and organize your thinking under the outline given below.

a) Make all the suggestions you can which you believe will explain why a person is cold in a room where the air temperature is 85° and the wall temperature is 50°. Give your reasons as to why you believe each of these suggestions will explain the phenomenon.

b) What kinds of evidence would you want to collect which would enable you to decide among your suggested hypotheses?

c) Now go over the suggestions which you have made above and select the one which you believe to be the "best" explanation and give your reasons for your selection.

Outline

1(*a*) Hypotheses suggested to explain why the person is cold in a room where the air temperature is 85°.
Hypothesis 1.
Reasons:
Hypothesis 2.
Reasons:
Hypothesis 3.
Reasons:

1(*b*) What kinds of evidence would you want to gather which would enable you to decide among the suggested hypotheses?

1(*c*) Which of the hypotheses above is the best, and why?

FU-e. Using factual generalizations as one basis for judging the validity of sources of information.—Students frequently have difficulty in judging the objectivity or reliability of the references consulted, particularly in relation to writings pertaining to controversial subjects.

Exercise 10.

One teacher employed class discussion and examined the notebook of the secretary of a student group to obtain evidence concerning students' ability to evaluate authorities. Their judgments were formed during the study of certain controversial topics, such as cancer, heredity and environment, and fossil remains of man. These topics offered an excellent opportunity to consider the motive, standing, and training of an authority as well as the factual basis which he presented. After several discussions of this kind which dealt with a variety of articles and books used as references, the class as a whole, again through discussion, attempted to formulate in their own words a summary of statements to be their guides in evaluating references in the future. The discussions themselves enabled the teacher to estimate improvement in the students' thinking. When their notions concerning the validity of authorities were found to be hazy, further occasions for making judgments were provided, and specific areas of difficulty were considered until class discussion indicated acceptable understanding of the main ideas. The following statements were found in the secretary's notebook:

1. To develop general understanding of a broad subject it is usually necessary to consult many references.
2. A science textbook or journal is more likely to contain accurate information concerning a scientific subject than is a popular book or magazine.
3. Recent science publications often have more science information than do older publications.

4. Encyclopedias are useful for information on many topics.
5. The best basis for the judgment of the value of a source is the training and purpose of the author.
6. In science there are some subjects on which equally good authorities do not fully agree.

Method Understandings (*MU*)

MU-a. Making proper qualifications when interpreting data.—This outcome has been defined in terms of seven specific principles: extrapolation, interpolation, sampling, reasoning by analogy, purpose and predetermined plan, value judgment, and cause and effect. The reader is urged to make a careful examination of the statement of these principles made by the Evaluation Staff of the Eight-Year Study.[9] This specific recommendation is made because many individuals who have considered the analysis and the associated testing materials regard this objective as the most important aspect of what is commonly known as the "scientific method."

Exercise 11.

One exercise is given below which has been taken from Test 2.52, "Interpretation of Data." In the "short answer" form of this test, fifteen statements follow each of ten sets of data. These statements have been constructed so as to involve the principles of interpretation indicated above.

Since a more complete description of the entire test can be found elsewhere,[10] only the coded answers to the statement are presented below. The purpose of this presentation is to indicate how the principles of interpretation are built into this particular test.

These Data Alone
(1) are sufficient to make the statement true.
(2) are sufficient to indicate that the statement is probably true.
(3) are not sufficient to indicate whether there is any degree of truth or falsity in the statement.
(4) are sufficient to indicate that the statement is probably false.
(5) are sufficient to make the statement false.

PROBLEM II. Below are given the results of an experiment with four groups of rats which were treated in various ways after being infected with pneumonia germs.

LOT I

Ten rats were infected with pneumonia germs, and immediately given anti-pneumonia serum.

Survivors

Of the ten rats in Lot I, nine recovered and one died from the infection with pneumonia germs.

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[9] Interpretation of Data, Test 2.52. Evaluation Staff of the Eight-Year Study, University of Chicago; 1: 240; 7: chap. ii.

[10] *Ibid.*

LOT II

Ten rats were infected with pneumonia germs and were inoculated with anti-pneumonia serum, in the same manner as Lot I, twelve hours after inoculation with the germs.

Survivors

Of the ten rats in Lot II, seven recovered and three died from the infection with pneumonia germs.

LOT III

Ten rats were infected with pneumonia germs and were inoculated with anti-pneumonia serum, in the same manner as Lot I, twenty-four hours after inoculation with the germs. By this time, thirty to sixty per cent of the lung tissue of each rat was affected.

Survivors

Of the ten rats in Lot III, five recovered and five died from the infection with pneumonia germs.

LOT IV

A control experiment was set up in which ten rats were infected with pneumonia germs at the same time and in the same manner as Lot I, but were not given anti-pneumonia serum.

Survivors

Of the ten rats in Lot IV, nine died and one survived the infection with pneumonia germs.

Statements

16. Anti-pneumonia serum was most effective in curing rats infected with pneumonia germs when the serum was given immediately after infection.
17. Infection and subsequent survival resulted in the development of an immunity to pneumonia in the sole surviving rat in Lot IV.
18. If the rats in Lot IV had been treated with anti-pneumonia serum immediately after being infected with the pneumonia germs, only one of the rats in Lot IV would have died.
19. No treatment at all was as effective as treatment with anti-pneumonia serum in reducing the death rate in rats that were infected with pneumonia germs.
20. Experiments in which animals are infected with harmful germs should be confined to rats.
21. If ten rats, similar to those in Lot II, had been infected with pneumonia germs and treated with anti-pneumonia serum twenty-four hours after infection, all of the rats would have survived.

22. The death rate in Lot II was due to the fact that from thirty to sixty per cent of the lung tissue was affected.
23. Human beings suffering from pneumonia would be likely to recover if they were given anti-pneumonia serum immediately.
24. If anti-pneumonia serum had been administered to the rats in Lot II six hours earlier, more than seventy per cent of the rats would have survived.
25. Such experiments as the one described in this problem are performed to show that early diagnosis and treatment of pneumonia are essential to recovery.
26. If twice as many white rats had been used in Lot III, about fifty per cent of the rats would have survived.
27. If a larger number of rats similar to those used in this experiment were infected with pneumonia germs and were not treated with anti-pneumonia serum, most of them would survive.
28. Nine of the ten rats in Lot I survived, but only one of the ten in Lot IV survived.
29. Other similar rats subjected to the same treatment as that used on Lot I would become ill, but most of them would survive.
30. In Lot I, if five hours had elapsed between the time of infection with pneumonia germs and the time of the inoculation with anti-pneumonia serum, all of the rats would have recovered from the infection.

Statement	*Response*	*Type of Statement*
16	1	Trend
17	3	Effect
18	3	Samp.
19	5	Cf. Tr.
20	3	Value
21	4	Samp.
22	3	Cause
23	3	Anal.
24	2	Int.
25	3	Purp.
26	2	Samp.
27	4	Samp.
28	1	Cf. Pts.
29	2	Samp.
30	4	Int.

	Code
Cf. Pts.	—Comparison of "Points"
Cf. Tr.	—Comparison of Trends
Tr.	—A major trend or generalization
Int.	—Interpolation
Ext.	—Extrapolation
Samp.	—Sampling
Purp.	—Purpose
Anal.	—Analogy
Cause	—Cause
Effect	—Effect
Value	—Value

Evidence concerning the student's understanding of principles of interpretation of data can also be obtained through written responses to a number of questions so directed that students must use certain principles of interpretation.

The following exercise consists of a series of questions which have

as their basis the "rat" data around which the test shown above was constructed. The analysis of written work such as that called for by Exercise 12 frequently throws considerable light on the student's understanding of principles of interpretation because he has the opportunity to explain his interpretation.

Exercise 12.

You are to comment on every question. Leave no question unanswered. If you do not understand what is asked for, or are unable to make the statement as indicated, be sure to state such difficulty.

1. In terms of these data alone, what do you believe you can say about the number of survivors in Lot I compared with the number of survivors in Lot IV?
2. In terms of these data alone, what do you believe you can say concerning the relation between (*a*) the effectiveness of anti-pneumonia serum and (*b*) the time elapsed between infection and inoculation?
3. In terms of these data alone, what do you believe you can say concerning the immunity to pneumonia of the surviving rats?
4. In terms of these data alone, what do you believe you can say concerning the desirability of infecting animals with harmful germs? Give reasons for your answer.
5. In terms of these data alone, what do you believe would have happened to the rats in Lot II if the anti-pneumonia serum had been administered six hours later than it was?
6. In terms of these data alone, what do you believe you can say would have happened if the number of rats in Lot III had been doubled?"

Exercise 13.

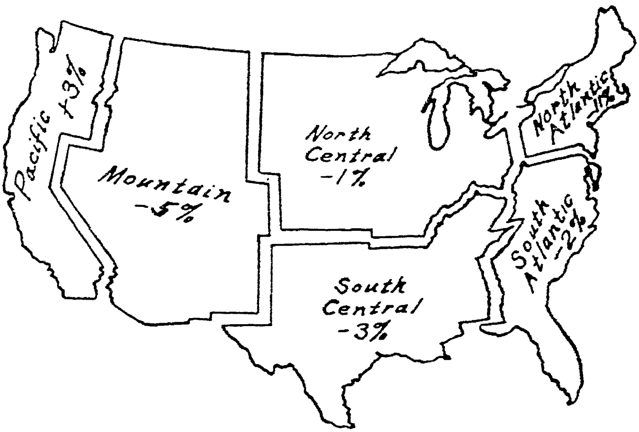
Certain distinctions between statements in Test 2.52 (pp. 120-22) are frequently difficult for students at the junior high school level. Particularly do students at this level find difficulty in distinguishing between a category in which they are to say that the evidence is totally insufficient, and one in which they say that the evidence suggests the probable truth or probable falsity of such a statement.

To overcome this difficulty another test[11] has been developed in which the student classifies an interpretation in one of three ways, such as in the following example:

A — enough information is given to make the statement *true*
U — not enough information is given to decide
D — enough information is given to make the statement *false*

[11] Test 2.71, Evaluation Staff of the Eight-Year Study, University of Chicago.

PER CENT OF CHANGE IN MOTOR FATALITIES (DEATHS) IN THE REGIONS OF THE UNITED STATES IN 1939 AS COMPARED WITH 1938



The above map shows for each region the percentage of increase or decrease in motor fatalities in 1939 as compared with 1938. A minus per cent means a decrease in deaths due to motor fatalities; a plus per cent means an increase in deaths due to motor fatalities. The per cent for the United States as a whole for 1939 is —2%, which means there were 2% less motor fatalities in the whole of the United States in 1939 than in 1938.

Statements

1. In 1939, there was a decrease in motor fatalities in most of the regions of the United States.
2. The per cent of decrease in motor fatalities was greater in the South Central region than in the North Central region.
3. The general decrease in motor death toll in the United States in 1939 is due in part to improved traffic laws.
4. The largest decrease in the per cent of motor fatalities in the regions of the United States occurred in the North Atlantic region.
5. In 1939, there were three times as many deaths due to motor accidents in the South Central region as in the North Central region.
6. There was a two per cent decrease in motor fatalities in Florida.
7. There were more motor fatalities in the Pacific region in 1939 than there were in 1938.
8. In 1939, more people were killed in motor accidents in the Pacific region than in the North Atlantic region.
9. The death rate due to motor fatalities is decreasing from year to year.
10. Such records will encourage traveling in the North Atlantic region.

An examination of the statements of the exercise above reveals that the same principles of interpretation, namely, principles of sampling, extrapolation and interpolation, cause and effect, etc., are built into this test as in the case of the previously discussed Test 2.52. The main distinction between the results expected of students in the two instances is that the level of discrimination in the applications of these principles is definitely lower in the last exercise.

Exercise 14.

The following exercise illustrates another test form used to collect evidence concerning the student's ability to interpret data (**6**: 403).

Directions: In each of the following exercises, an experiment is described. Below the description of the experiment are several statements which have been suggested as interpretations of the experiment. Assume that the facts given in the description of the experiment and in the results obtained are correct; then, on the basis of these facts only, consider each statement.

Mark with "1"—every statement which is a reasonable interpretation of the results obtained.
"2"—every statement which might possibly be true but for which insufficient facts are given to justify the interpretation.
"3"—every statement which cannot be true because it is contradicted by the results obtained in the experiment.

The sample shows what you are to do.

Sample: In an experiment some white starch was treated with brown iodine solution. This was done ten times and each time a blue color was formed.

Later some white starch was mixed with saliva. The mixture was left for a time and then it was treated with brown iodine solution. This was done ten times and each time no blue color was formed.

a) The starch was changed to sugar by the action of saliva........(2) *a*
b) Saliva digested the starch.................................(2) *b*
c) Starch acted upon the iodine...............................(1) *c*
d) Saliva produced a change in the starch.....................(1) *d*
e) Starch mixed with iodine solution did not turn blue...........(3) *e*

Exercise 15.

In a unit on living and nonliving things, students were asked first to indicate specific differences and similarities between fish and water. Such differences and similarities were recorded on the board as they were stated. The students were then asked to make an interpretation of the available evidence, following these instructions: "On the basis of this analysis *alone* write a generalization about the difference be-

tween living and nonliving things." Students' responses showed varying degrees of recognition of need for qualifying their generalizations on the basis of the inadequacy of the sample. Some students wrote, "Living things are yellow, spindle-shaped, move rapidly, breathe; while nonliving things have no definite shape or color, cannot move, do not see, eat, or breathe." More cautious students answered as follows: "From one example of each type, no generalization can be made," or "If all these things are like fish, then all nonliving things are like water, then all living things are yellow, spindle-shaped, etc." This analysis was extended into a discussion of the Gallup and Literary Digest Polls concerning methods of obtaining evidence, together with the conclusions to be drawn from such evidence.

At the end of several days of work during which attention was given primarily to the issues involving the adequacy of the sample, the secretary of one class summarized the discussion as follows:

1. The more representative a sample is, the more acceptable the generalization made on it.
2. The less representative the sample, the less certain one can be of the truth of a generalization from the data.
3. A large sample is not always a good representative sample.
4. One sample is sufficient if a substance is homogeneous.
5. If samples are well chosen and fairly large, they will represent the entire group faithfully.

MU-b. Identifying necessary and unstated assumptions involved in a conclusion, prediction, course of action, or practice.—Another outcome involving a method of science consists of abilities and attitudes toward the identification of unstated assumptions implied in a conclusion or course of action. Such abilities and attitudes mean, for example, that the student recognizes that a conclusion is no stronger than the weakest assumption in the line of reasoning utilized in arriving at the conclusion. Frequently, it is necessary to identify what are called necessary and sufficient conditions or assumptions. Other assumptions involve the competence and integrity of a source.

The following samples have been taken from certain testing materials which have as their purpose the recognition and, in some cases the appraisal, of assumptions.

Exercise 16.

In this part of the test[12] you are given a statement of facts and a conclusion which has been drawn from the facts. The conclusions are not com-

[12] "Ohio Every Pupil Test," 1938. Columbus, Ohio: Ohio State Department of Education.

pletely justified by the facts given. They may be justified, however, if certain assumptions are made; that is, if certain factors not given in the statement of facts are taken for granted. You are to select those factors which have been taken for granted by checking them on the line at the left of the statement. In some of the problems you are asked to select only one assumption and in others more than one.

Statement of Facts: The following table represents the relationship between the yearly income of certain families and the medical attention they receive.

Family Income	Per Cent of Family Members Who Received No Medical Attention During the Year
Under $1200	47
$1200 to $3000	40
$3000 to $5000	33
$5000 to $10,000	24
Over $10,000	14

Conclusion: Members of families with small incomes are healthier than members of families with large incomes.

Assumption: (Select one)

_______ (1) Wealthy families had more money to spend for medical care.
_______ (2) All members of families who needed medical attention received it.
_______ (3) Many members of families with low incomes were not able to pay their doctor bills.
_______ (4) Members of families with low incomes often did not receive medical attention.

Exercise 17.

Test items of the essay or verbal type in which students are asked to make essentially the same type of response as that requested in the above exercise are relatively easy to construct. The following example is illustrative.

Statement of Facts:

Family Income	Per Cent of Family Members Who Received No Medical Attention During the Year
Under $1200	47
$1200 to $3000	40
$3000 to $5000	33
$5000 to $10,000	24
Over $10,000	14

Conclusion: Members of families with small incomes are healthier than members with large incomes.

The conclusion is not completely justified by the facts given. It may be justified, however, if an assumption is made; that is, if a factor not stated in the given facts is taken for granted. What is this factor? That is, what must be assumed in addition to the facts given in order that the conclusion be true?

In the following exercise the student is asked to indicate assumptions stated in the form of questions. Some of the questions challenge the data given, but most of them represent unstated assumptions involved in the conclusion.

Exercise 18.[13]

A number of diseases have been identified as deficiency diseases; that is, they result from a deficiency of certain substances in the diet. The better known of these substances are vitamins A, B, C, and D. During recent years these vitamins have been placed on the market in the form of capsules which are sold widely. The unrestricted sale of these capsules has been of some concern to the medical profession primarily because of a possible tendency on the part of people to consider the vitamin capsule as a drug preparation and as a "cure-all" for digestive disturbances, run-down feeling, etc. Recently the following statement appeared in the magazine, *Hygeia:*

"The doctors have no quarrel with vitamins. Every man, woman, and child needs a normal supply every day to keep well. A lack of vitamins may result in what doctors call 'deficiency diseases.' But the reason these deficiency diseases are not common in America is that most people get all the vitamins they need simply by eating three adequate meals a day. This is just the way grandpop got his vitamins before they were discovered."

A person reading this selection decided that *buying vitaman capsules is a sheer waste of money because "deficiency diseases" are practically nonexistent in America.*

Part A. In judging the truth of the conclusion that "buying capsules is sheer waste of money because deficiency diseases are practically nonexistent in America," what questions do you believe should be answered before making a decision? From the following list select *not more than four* questions you believe most pertinent. Place a check mark in the parentheses preceding each question you select. Pay no attention now to the columns numbered 1, 2, 3.

[13] "Health Inventory," 1.5. Cooperative Study in General Education, University of Chicago.

QUESTIONS

1 2 3

___ ___ ___ ( ) Would a company make and sell vitamin capsules if it did not believe there was a real need for them?

___ ___ ___ ( ) Will the use of vitamin capsules be harmful to one's health?

___ ___ ___ ( ) Are deficiency diseases uncommon in America?

___ ___ ___ ( ) Is the medical profession in a position to know whether deficiency diseases are practically nonexistent?

___ ___ ___ ( ) Do people use vitamin capsules as a cure for digestive disturbances and a rundown feeling?

___ ___ ___ ( ) Is it generally true that companies sell any product they can regardless of the need for or the effect of the product?

___ ___ ___ ( ) Is it not probable that doctors will be ignorant of many cases of deficiency disease because such people cannot afford a doctor?

___ ___ ___ ( ) Is a substance prepared artificially, such as vitamin capsules, harmful if it is not needed by the body?

___ ___ ___ ( ) Does everyone receive necessary vitamins by means of three adequate meals daily ?

Part B. After you have made your selection in Part A you are to judge *all* of the questions in the following manner. Check the space corresponding to the number of the question in:

Column 1, if you are quite sure that the answer to the question is *yes* or *usually yes*.

Column 2, if you are quite sure that the answer is *no* or *usually no*.

Column 3, if you are *uncertain* about the answer to the question.

The following item[14] was taken from a test used with junior high school students.

Exercise 19.

Judging evidence and conclusions. In a radio broadcast the following story was told by the speaker:

"A little mining town in Pennsylvania gets all of its water from a clear mountain stream. In a cabin on the bank of the stream above the town one of two campers was sick with typhoid fever during the winter. His waste materials were thrown on the snow. In the spring the melting snow and other water ran into the stream. In several days after the snow melted typhoid fever and death struck the town. Many of the people became sick and 114 people died." The speaker then said that this story showed how the sickness of one man caused *sickness and death among many people.*

[14] "Evaluation of School Broadcasts." Columbus, Ohio: Ohio State University. Bureau of Educational Research Bulletin No. 1, May, 1939. Columbus, Ohio: Ohio State University (mimeographed).

Part A. *Directions:* Below is a list of statements about the story. If you were to say that the man's sickness caused the sickness and death in the town, you may believe some or all of the statements. If a statement says something that an intelligent person should believe, then mark it as *true*.

Part B. *Directions:* If you were to decide that the man's sickness caused the sickness and death in the town, you would want to be sure about several things before you made that decision. Read the statements below again and check (√) the three which you believe are the most important to be sure about before you should decide that the *man's sickness caused the sickness and death in the town. Do not check more than three.*

Part A: I believe the statement is true. Yes	No	*Statements*	Part B
_____	_____	*a.* Water in mountain streams usually becomes pure as it runs over rocks.	_____ *a.*
_____	_____	*b.* Typhoid fever germs in drinking water may cause typhoid fever.	_____ *b.*
_____	_____	*c.* All of the drinking water of a small town like this one came from the mountain stream.	_____ *c.*
_____	_____	*d.* In a small town like this one there would not be nearly as many people sick at the same time with typhoid as the story tells.	_____ *d.*
_____	_____	*e.* Typhoid germs were the only kind of germs in the water.	_____ *e.*
_____	_____	*f.* There was no other possible way of getting typhoid —such as an impure milk supply in the town.	_____ *f.*
_____	_____	*g.* Typhoid fever germs did not get into the stream from some source other than from the sick man.	_____ *g.*
_____	_____	*h.* A person by himself, like the camper, can get typhoid.	_____ *h.*
_____	_____	*i.* Typhoid fever would break out in several days after the snow melted.	_____ *i.*
_____	_____	*j.* The typhoid fever germs are not killed when thrown on snow.	_____ *j.*

The distinction between the assumptions or postulates involved in major theories of science and the evidence also supporting such theories is asked for in certain kinds of test items developed in the University of Chicago general course examination.[15] One illustration of how such distinctions can be made is given in the following example:

[15] Physical Science Examination, University of Chicago, 1940.

Exercise 20.

Understanding of theories. In this question you are to give the experimental bases for and the assumptions involved in several different theories of physical sciences.

Observational basis for the Kinetic-Molecular theory. In the Kinetic-Molecular theory the assertion is made that the molecules are in continual haphazard motion.

Which one or ones of the following statements represent *observational evidence* which helps to justify the above assertion?

A. Cyclones often produce serious destructive effects.
B. Air warmed by the radiator in a room rises to the ceiling.
C. Very small particles of carbon in suspension are observed to execute irregular motion (Brownian Movement).
D. A quantity of a gas like chlorine, when released, diffuses through another gas.
E. On colliding, molecules lose no energy.

In the Kinetic-Molecular theory the assertion is made that attractive forces exist between the molecules of a substance.

Which one or ones of the following statements represent *observational evidence* which helps to justify the above assertion?

A. By a sufficient increase in pressure and a sufficient decrease in temperature, a gas may be liquefied or solidified.
B. Heat must be supplied to change water into steam.
C. Hydrogen and oxygen combine to form water.
D. One gas released in the presence of a second gas quickly mixes with the second.
E. Many real gases obey the General Gas law ($\frac{PV}{T} = K$).

Assumptions involved in the Kinetic-Molecular theory. In the Kinetic-Molecular theory the assertion is made that the pressure of a gas is due to the impact of molecules against the sides of the container. Which of the following statements represent *assumptions* (not observational evidence) involved in the above assertion?

A. The pressure of a gas is proportional to the absolute temperature.
B. Molecules are in motion.
C. Molecules of a gas have mass.
D. There exist attractive forces between the molecules of the gas.
E. Newton's laws of motion apply to molecules.

In the Kinetic-Molecular theory the assertion is made that, when partial evaporation of a liquid occurs in the absence of an external source of heat, the average kinetic energy of the molecules of the liquid is reduced.

Which one or ones of the following statements represent(s) *assumption(s)* (not observational evidence) involved in the above assertion?

A. Not all molecules move with the same speed.

B. The faster-moving molecules escape from the liquid.
C. Molecules of a liquid, when moving in the region above the liquid, give rise to a vapor pressure.
D. Heat must be supplied to vaporize a liquid at constant temperature.
E. Much less space exists between molecules of a liquid than between molecules of a gas.

MU-c. Recognizing and using defensible arguments or reasons when justifying a prediction, course of action, or practice.—An understanding of the elements of the scientific method enables the student to justify his conclusions on a rational basis. Such elements mean that the student can organize an argument by citing relevant evidence and the assumptions upon which a conclusion rests, by recognizing valid and invalid analogy, by avoiding argument which essentially repeats the conclusion, by proper use of the "if-then" principle of argument, and by other elements of proper reasoning.

The following example represents a problem taken from an early form of a test, "Nature of Proof," developed by the Evaluation Staff of the Eight-Year Study. For a more complete analysis and definition of desirable outcomes, the reader is urged to read the discussion of the nature of proof in the report of the Commission on the Relation of School and College (7: 126-54).

Exercise 21.

Are you learning to recognize and evaluate assumptions?

A small piece of magnesium will ignite and burn with a bright light in an atmosphere of chlorine gas, leaving white ashes. Bill secured some chemicals which, when mixed together and heated, gave off a colored gas. He collected some of this gas in a bottle. The chemistry teacher gave him a small piece of magnesium. Bill put it in the bottle of colored gas. The magnesium ignited, burned with a bright light, and left white ashes. Bill told his friends that his results conclusively proved that the colored gas was chlorine.

Part 1. *Directions:* Read each statement below. Is the statement a FACT, or is it an ASSUMPTION? Place a check mark (√)in the appropriate column *before* the statement.

Part 2. *Directions:* Read over again only those statements which you have marked as *assumptions*. Place a check mark (√) after those TWO ASSUMPTIONS which are absolutely necessary in proving that the gas was chlorine. Do not mark more than two.

Fact	Assumption	Statements		
_____	_____	*a.* Chlorine is not the only gas in which magnesium will burn with a bright light and leave white ashes	_____	*a.*
_____	_____	*b.* The material the chemistry teacher gave him was magnesium.	_____	*b.*
_____	_____	*c.* Chlorine gas is the only gas in which magnesium will ignite.	_____	*c.*
_____	_____	*d.* Chlorine gas is the only gas in which magnesium will ignite, burn with a bright light, leaving white ashes.	_____	*d.*
_____	_____	*e.* Bill mixed and heated some chemicals which gave off a colored gas.	_____	*e.*
_____	_____	*f.* A small piece of magnesium will ignite and burn with a bright light in an atmosphere of chlorine gas, leaving white ashes.	_____	*f.*
_____	_____	*g.* Chlorine gas is the only gas in which magnesium will burn with a bright light.	_____	*g.*
_____	_____	*h.* Bill collected some of the colored gas in a bottle.	_____	*h.*
_____	_____	*i.* The properties of the colored gas in the bottle were the only cause of the magnesium igniting, burning with a bright light, and leaving white ashes.	_____	*i.*
_____	_____	*j.* Bill put a small piece of magnesium in the bottle.	_____	*j.*
_____	_____	*k.* The properties of the colored gas in the bottle were not the cause of the magnesium igniting, burning with a bright light, and leaving white ashes.	_____	*k.*
_____	_____	*l.* The magnesium ignited, burned with bright light, and left white ashes.	_____	*l.*

Are you learning how to develop a logical proof?

When arguments for or against some proposition are presented in newspapers, magazines, speeches, or textbooks, we often feel that the discussion could have been made more logical. Authors sometimes put in statements that are really unnecessary to prove their point; at other times they leave out important arguments; on still other occasions they arrange their statements in such poor order that the conclusion does not seem to be based on or to grow out of the arguments.

Part 3. *Directions:* Suppose *you* were describing this experiment in order to prove that chlorine gas was collected. What are all of the *absolutely* necessary statements in the complete development of the proof? Use as many of the above statements as are necessary and place the letters of these statements in their proper order[16] on the line below. Do not use any unnecessary statements.

[16] Although the test requests "proper" order, various orders are equally acceptable and the test has been scored in terms of whether all relevant facts and assumptions are included.

Are you learning to support your own conclusions with sound arguments?

Part. 4. *Directions:* In Part 3 of this test you presented a logically developed proof which reached the conclusion that the colored gas Bill made must be chlorine. You may or may not believe that it has been adequately proved that the colored gas must be chlorine. Check the following statement which best represents your own personal opinion as to the nature of the gas.

_____ *a.* I believe that the colored gas Bill made was chlorine.

_____ *b.* I do not believe that the colored gas Bill made was chlorine.

_____ *c.* I do not believe that it has been adequately proved that the colored gas Bill made was chlorine.

Write out the reasons you have to support your opinion.

Evidence concerning the student's understanding of good and poor analogy, avoiding a repetition of a conclusion and certain other elements of good reasoning may be obtained from an analysis of his responses to test items constructed like one described under FU-*b*, "Applying Principles."

MU-d. Identifying valid cause-and-effect relationships when interpreting a phenomenon.—Cause-and-effect generalizations which relate important scientific phenomena are difficult for students to grasp. Such relationships require caution as well as a clear-cut understanding of valid physical and biological science principles.

The following exercises have been selected from tests designed to obtain evidence concerning the student's understanding of cause-and-effect relationships.

Exercise 22.

Directions:[17] One characteristic of a scientist is that he believes that every effect has a cause and he tries to discover these cause-and-effect relationships.

For example: When a piece of iron is heated, it expands.
Heating the iron is the cause.
Expansion of the iron is the effect.

Below are statements similar to the above. Read each statement. On the line at the right, place the capital letter corresponding to one of the following relationships:

Relationships

A. The first part of the statement is the cause of the second part.
B. The first part of the statement is the result of the second part.
C. The two parts have no cause-and-effect relationship.
D. One part of the statement contradicts the other.

[17] "Ninth-Grade Science Examination," 1935. Rochester, New York: Board of Education.

Statements

1. Plants make food when the sun shines. 1. ______
2. Air contains oxygen and also nitrogen. 2. ______
3. A bulging forehead indicates a brilliant mind. 3. ______
4. John walked under a ladder and he failed in science. 4. ______
5. The draft is opened; the fire burns more rapidly. 5. ______
6. When the moon passes between the earth and sun, the sun is not visible. 6. ______
7. When a dish full of cold water is heated, the water overflows. 7. ______
8. When cold air is heated, the relative humidity increases. 8. ______
9. Growing yeast plants give off CO_2; therefore, there are holes in the bread. 9. ______
10. Wiley Post wore an oxygen helmet; his plane worked perfectly. 10. ______

Exercise 23.

Tell whether each of the statements following the fact is (A) a cause of the fact, (B) a result of the fact, or (C) not related to the fact.[18]

FACT: A flash of lightning occurs.

Statements

3. A roar of thunder can be heard. 3. ______
4. Electricity passed between clouds and the earth. 4. ______
5. It is dangerous to stand under a tree during a rainstorm. 5. ______

FACT: Metals expand when heated.

Statements

12. The molecules of metal become farther apart when heated. 12. ______
13. When the temperature increases, the mercury in the thermometer rises. 13. ______
14. Telephone wires are slack in summer and tighter in winter. 14. ______

Exercise 24.

The State Science Committee of Wisconsin[19] has designed a test in which a list of paired occurrences is given, and students are asked to check indicating whether:

A. The first is the sole cause of the second.
B. The first is one of a number of contributing causes of the second.
C. The first contributes slightly to the second.
D. Both are results of the same cause.

[18] Eighth Grade General Science Examination, 1936. Rochester, New York: Board of Education.

[19] The Science Committee, Wisconsin State Education Association, Madison, Wisconsin.

E. The first bears no causal relationship to the second.

Sample test items:

1. The branches of a tree move to and fro; a nearby windmill turns. 1. ______
2. Heat of sunlight; warmth of earth. 2. ______
3. A woman dropped a dish on the floor; the dish broke. 3. ______
4. A fruit can was opened; the fruit in the can spoiled. 4. ______

Concluding Statement

The foregoing suggestions for evaluating understandings which result from science instruction obviously represent but a sample of those which have been developed by test constructors and classroom teachers. Furthermore, no effort has been made to present tests which are complete from the standpoint of sampling a variety of situations or topics.

Two points, almost axiomatic but frequently overlooked, should be noted in connection with the use of evaluation devices. First, the particular devices used for evaluating a student's understanding in science should correspond to the ideas dealt with directly in day-by-day instruction. If an objective such as "applying principles to new problems" is not a real part of everyday instruction, there is little reason to expect students to demonstrate any appreciable proficiency in applying principles. Important objectives must be "taught for" directly—they are not by-products of instruction. To insure a maximum amount of achievement in any important objective, it is also imperative that a continuous cycle of teaching-evaluation-teaching occur. Only in this way can a significant improvement in the student's understanding take place (see chapter ii).

A second point concerning the use of evaluation devices involves their construction. The alternative responses of an objective test should be planned in such a way that "wrong" responses are as revealing as are right ones. This means that the teacher has the responsibility of indicating both to himself and to his students the basis of failure in achieving understanding. In the case of "essay" or "verbal" testing devices, the questions to which students are to respond must be directed toward the specific desired behavior, although the student himself may or may not be conscious of this "direction."

One last word: The material presented in this chapter has emphasized formal paper-and-pencil testing. Some of the illustrative tests are rather elaborate and complicated, such, for example, as Exercises 5, 11, 18, and 19. Tests of this kind are difficult to prepare, and interpretation of the responses secured is no easy matter. They have

been included here, however, to show the possibilities of such tests in the hands of the expert—to set, as it were, a sort of "ceiling" for practice. On the other hand, paper-and-pencil tests which get at understanding but are of a simpler character, well within the capacity of the average classroom teacher to construct, have also been exemplified. Other illustrative techniques, few in number, have shown how the out-of-school activity of students may be examined for evidence of understanding (Exercise 8) and how class discussion and class reports may be used to the same end (Exercise 10). Nevertheless, the fact remains that this chapter has stressed paper-and-pencil testing.

Yet, as stated in chapters iii and iv, much evidence of growth in understanding is available in the everyday activities of the classroom.

Some teachers keep permanent records of their observations, having a folder for each of their students. At the end of the semester or of the year, these folders are sources of rich information with regard to students' changes in understanding. But such permanent records are not essential for the purposes of evaluation. The alert teacher of science, by noting occurrences of student behavior which signify insight into what is being taught, can from day to day secure concrete data to broaden and deepen his knowledge concerning his students' progress in understanding.

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CHAPTER VII
THE MEASUREMENT OF UNDERSTANDING IN ELEMENTARY-SCHOOL MATHEMATICS

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THE AIMS OF ELEMENTARY-SCHOOL MATHEMATICS

During the past decade an increasing number of schools have been using the term *elementary-school mathematics* to replace *arithmetic* in courses of study and in school reports. This change is no mere whimsey. It is indicative of a corresponding broadening of our vision of the content and function of arithmetic or mathematics in the elementary school. To many school people the word "arithmetic" was synonomous with computation; and arithmetic was merely a tool to be called forth when a need was recognized. More recent literature has called attention to the breadth of aims that should be achieved. For example, in one discussion of curriculum problems in this field, the following classification of aims is employed: (*a*) concepts and vocabulary, (*b*) principles and relationships, (*c*) social and economic information, (*d*) factual information and materials, (*e*) processes and manipulations, (*f*) problems and basic thought patterns, and (*g*) reflections and judgments.[1]

The breadth of aims and their interrelations may be illustrated by a discussion of the unit of measure *quart*. The *concept* of *quart* functions in descriptive situations that range from simple visual and manual impressions to a mental visualization which must be conjured out of

[1] *Arithmetic in General Education*, p. 21. Sixteenth Yearbook of the National Council of Teachers of Mathematics. New York: Teachers College, Columbia University, 1941.

a complex situation presented in either oral or written form. The concept of *quart* involves impressions of its size; of size in relation to shape, to use, and to weight. The concept is developed in relation to quarts of things, in relation to other standard measures such as pint and gallon, and to such less definitive units as cupful, canful, and other containers used in the home and school. Closely associated with the concept of *quart* is a wealth of information about its use. It may be a measuring can, a tall bottle of gingerale, a squat can of paint, or a brick of ice cream. Further associations are of the type, "A quart of ice cream is enough for six people," "We use two quarts of milk per day," and "A quart of paint is not enough for this floor."

The *quart* becomes involved in *mathematical relationships* of the type, "A quart is a quarter of a gallon," and the reciprocal, "A gallon equals four quarts." These relationships lead to computations of multiplication and division as quarts are changed to pints, gallons, or other units of measure. Out of these changes comes the generalization, "In any given quantity, the smaller the unit of measure the more of them, and the larger the measure the fewer of them." The *quart* becomes further involved in *computations* as quarts of things are combined (added), removed or compared (subtracted), combined in equal multiples (multiplied), and sectioned or compared as ratios (divided). Many other computations arise as quarts of things are bought and sold.

Attitudes and *appreciations* are developed in relation to the *quart*. The child who is required to drink daily a quart of milk that he does not relish develops a different attitude toward *quart* than does the child who shares liberally in a quart of ice cream that he enjoys. Frequently it is found that children do not fully understand *quart*. Many do not know that the liquid quart differs from the dry quart in size and uses. Likewise it is not uncommon to find pupils who do not comprehend the sameness of a quart of milk in a bottle, a quart of paint in a can, and a quart of water spilled on the floor. In Grades VII and VIII the *quart* becomes further involved in mathematics as the principles of percentage are developed and used.

It is the interrelationship of the mathematical elements that lifts arithmetic from the *tools-for-use* level of education and makes it imperative that the teacher be thoroughly schooled in its subject matter. The teacher must know these mathematical elements as well as their social, cultural, and economic uses and implications.

Not many statements of aims and objectives have been formulated and published since our vision of arithmetic has broadened and since *meaning* and *understanding* have come to be stressed. A very

full list of goals can be found in the "Sequential Learnings Chart" of the New York State Syllabus.[2] For the discussion here, we have chosen Brownell's statement of aims published in the Sixteenth Yearbook of the National Council of Teachers of Mathematics.[3]

Aims or Desired Outcomes

1. Computational skill:

   Facility and accuracy in operations with whole numbers, common fractions, decimals, and per cents. (This group of outcomes is here separated from the second and third groups which follow because it *can* be isolated for measurement. In this separation much is lost, for computation without understanding *when* as well as *how* to compute is a rather empty skill. Actually computation is important only as it contributes to social ends).

2. Mathematical understandings:

   a) Meaningful conceptions of quantity, of the number system, of whole numbers, of common fractions, of decimals, of per cents, of measures, etc.
   b) A meaningful vocabulary of the useful technical terms of arithmetic which designate quantitative ideas and the relationships between them.
   c) Grasp of important arithmetical generalizations.
   d) Understanding of the meanings and mathematical functions of the fundamental operations.
   e) Understanding of the meanings of measures and of measurement as a process.
   f) Understanding of important arithmetical relationships, such as those which function in reasonably sound estimations and approximations, in accurate checking, and in ingenious and resourceful solutions.
   g) Some understanding of the rational principles which govern number relations and computational procedures.

3. Sensitiveness to number in social situations and the habit of using number effectively in such situations:

   a) Vocabulary of selected quantitative terms of common usage (such as kilowatt hour, miles per hour, decrease and increase, and terms important in insurance, investments, business practices, etc.)
   b) Knowledge of selected business practices and other economic applications of number.
   c) Ability to use and interpret graphs, simple statistics, and tabular pre-

[2] *Mathematics for Elementary Schools,* insert p. 34. Albany, New York: University of the State of New York, 1937.

[3] Op. cit., pp. 231-32. Consult the latter part of the chapter for a large number of suggested evaluation procedures.

sentations of quantitative data (as in study in school and in practical activities outside of school).

d) Awareness of the usefulness of quantity and number in dealing with many aspects of life. Here belongs some understanding of social institutions in which the quantitative aspect is prominent, as well as some understanding of the important contribution of number in their evolution.

e) Tendency to sense the quantitative as part of normal experience, including vicarious experience, as in reading, in observation, and in projected activity and imaginative thinking.

f) Ability to make (and the habit of making) sound judgments with respect to practical quantitative problems.

g) Disposition to extend one's sensitiveness to the quantitative as this occurs socially and to improve and extend one's ability to deal effectively with the quantitative when so encountered or discovered.

Techniques of Measuring Understanding

Understandings in Computation

The Role of Computation. In the real world (outside of schools and workbooks) computation usually follows a preliminary judgment or it comes as a step in reaching and checking a final judgment. In other words, one seldom, in the practical affairs of life, computes merely for the sake of computing; computation is not an end in itself. For this reason, computations in school should not be viewed merely as mechanical skills which justify themselves. Instead, computations should be taught and learned as parts of complete mathematical situations in which the computations are called into use. In order to obtain correct and effective final judgments and answers in a mathematical situation the pupil must (*a*) know what computational processes to use and (*b*) use these processes with facility and accuracy. In both of these stages it is the presence of the factors of *meaning* and *understanding* that raises the performance of the pupil above that of a computing machine.

Modes of Measuring and Evaluating Computations. The usual procedures for evaluation include (1) the use of written tests, (2) observation of the daily work of pupils, (3) interview of the pupils during and after their work, and (4) self-evaluation by the pupils themselves. For the measurement of understanding, a combination of all of these methods is most fruitful. Written tests are useful when they have been prepared for a specific purpose. Observation and interview are particularly valuable because they reveal *when* and *how* errors have been made. This is true for errors both of procedure and

of basic computations. For example, to find the cost per pound of frozen lima beans when a 12-ounce package sells for 27¢, the following wrong procedures were used by certain pupils in a class.

(1) $27 \div \frac{3}{4}$

$$\frac{\overset{1}{\cancel{3}}}{4} \times \frac{1}{\underset{9}{\cancel{27}}} = 36$$

(2)

$$\begin{array}{r} 2 \\ 12\overline{)\,27} \\ 24 \\ \hline 3 \end{array}$$

$$\begin{array}{r} 2 \times 16 = 32 \\ + \;\; 3 \\ \hline 35 \end{array}$$

(3)

$$\frac{\overset{3}{\cancel{12}}}{\underset{4}{\cancel{16}}} \times 27 = \frac{81}{4} = 21$$

An interview showed that each pupil had a plan or reason. Pupil (1) said, "I changed the fractions. Isn't 36 the right answer?" He was disturbed because on many occasions he had been getting correct answers by his method which the teacher now explained to be wrong. Pupil (2) said, "You add in the remainder." Pupil (3) said, "You times it, don't you?" He was not even conscious of the fact that a pound should cost more than a fraction of a pound.

Measurement and evaluation are really stages of a complete learning process and not ends in themselves. Hence it is most important that the errors of understanding as well as those of abstract process be discovered when they are made so that correct learning may proceed. The exercises described above show how important it is for a school to provide instruction in the developmental phases of computational procedures.

Real and Reasonable Computations. Pupils grasp and understand exercises with small whole numbers much more readily than they do those with large numbers, fractions, and decimals. However, if they really understand the principles involved, they should be able to extend these principles into both (a) more complex socio-economic situations and (b) exercises with large or peculiar numbers. Both of these extensions may be measured either orally or by written exercises. For example, exercises (2) and (3) in the following list are extensions of exercise (1).

1. **How much will a dozen pencils cost at 5¢ each?**
2. **A truckman can haul six loads of gravel in the forenoon and six more loads in the afternoon. His truck holds six tons. How much can he plan to deliver per day?**
3. **If a boatload of 264,780 pounds of bananas is sold at $.05$\frac{3}{4}$ per pound, what is the total price?**

Pupils may be asked to state problems similar to a type problem that uses a particular process. These may be fanciful and unreal, for pupils generally have not had sufficient experience with trades and professions and with business practices to know which combinations of numbers may be reasonable and which do not ordinarily exist.

It has become school practice to limit computations to such as may reasonably occur in the more common trades and businesses. A comprehensive knowledge of many social, economic, and cultural situations is necessary in order to understand whether or not a particular abstract computation is a reasonable one. Consider the following problems.

(1) $\begin{array}{r} 3\frac{1}{2} \\ +\ 4\frac{1}{7} \\ \hline \end{array}$ (2) $\begin{array}{r} 3\frac{1}{3} \\ -\ 1\frac{2}{5} \\ \hline \end{array}$ (3) $\frac{11}{31} \times 208$ (4) $88\frac{1}{2} \div 3\frac{1}{7}$

Exercises (1) and (2) rarely, if ever, occur in the real world. The real fractions that are added and subtracted are usually related: they come in families, as, for example, halves, fourths, and eighths. Exercises (3) and (4) are real, the former in the case of a fractional part of a month's production, the latter in work with circles. In the multiplication and division of fractions large and peculiar combinations of numbers arise. Although the pupil cannot understand many of the limitations and uses of numbers in processes, his arithmetic will be more meaningful if, through discussion, he develops an alertness to reality.

Understanding in computations. There are several kinds of understanding associated with computations. One kind is understanding the usefulness of a process, as, for example, that addition is used for combining and grouping. Questions such as the following are suitable for this group of understandings and may be used in paper-and-pencil tests followed by discussion.

1. John has 7 marbles, George has 15, and Pete has 12 marbles. How can you find how many all three boys have?
2. If you know how many baby chicks Mr. Allen bought and how many have died, how can you find the number he has left?
3. Can you state a problem that uses multiplication? Now make one that uses both multiplication and subtraction.
4. Can you make a list of ten different kinds of problems? Use the signs $+$, $-$, $\times$, and $\div$ to show how these problems should be solved.

Here it should be pointed out that a given mathematical situation need not call for a unique solution. The resourceful pupil frequently finds an "easy way." To find which is the better value, (*a*) 2 cans for 15¢ or (*b*) 3 cans for 25¢, the following methods were used by different members of a class.

(1) $2\overline{)15}$ quotient $7\frac{1}{2}$ $3\overline{)25}$ quotient $8\frac{1}{3}$ (2) $3 \times 15 = 45$, $2 \times 25 = 50$ (3) $25 - 15 = 10$

The pupil who used method (3) arrived at the correct answer by reasoning that the 10¢ extra for the third can in "3 for 25¢" was too much. Observation and interview of pupils will frequently reveal an ingenuity based upon real understanding.

A second type of understanding in computations is based upon the relation of one process to another, as, for example, the relation of addition to subtraction or to multiplication. Questions of this type follow.

1. $6 + 18 = 24$ $18 + ? = 24$ $24 - 6 = ?$
2. Karen's allowance for the past 7 weeks was 25¢ per week. Find the total amount of her allowance in two different ways.
3. How many $3\frac{1}{2}$-yard dress lengths can be sold from a 15-yard piece of cloth, and how much will remain in the remnant? Show how to do this by (*a*) measuring, (*b*) subtracting, and (*c*) dividing.
4. Show how to check a multiplication exercise by dividing. Why does this check work?

A third type of understanding deals with the technical mathematical relationships in a process, such as "carrying" in addition. Questions such as the following may be used.

1. Have you watched the mileage register on a speedometer? What happens when a 9 in one space changes to the next higher number? How is this like carrying in addition?
2. To find the cost of 6 things at 12¢ each, you multiply, as: $\begin{array}{r} 12 \\ \times\ 6 \\ \hline \end{array}$ How would you find the cost of 125 papers at 3¢ each? Does $125 \times 3 = 3 \times 125$?
3. How can you pay me a dollar and a quarter when all you have is a $5 bill? Show how the number 5 must be changed when you want to subtract, as in $5 - 1\frac{1}{4}$.

In exercises such as the above, interview and discussion serve best to show degrees of understanding by individual pupils.

A fourth type of understanding associated with computations depends upon a general mathematical sensing of the number relationships and leads to an appreciation of reasonableness in results, as, when a number is multiplied by four the answer should be *four* times as large and not *forty* or *one-fourth* times as large. Exercises such as the following are suggestive.

1. Henry worked several problems and obtained these answers. Which answers do you think are correct?

a) Bicycle costs $295 *b*) Can of peas costs $0.18
c) Man weighs 192 lbs. *d*) Boy walks 30 mi. per hr.

2. In the following exercises, the word *numbers* includes whole numbers, fractions, and decimals. Pick out the statements that are always true. Make an example to illustrate those that are sometimes false.
   a) When a group of numbers is added, the sum is always larger than the largest number.
   b) The product of two numbers is more than the larger of the two numbers which were multiplied.
   c) Any number divided by itself has a quotient of 1.
   d) When any number is multiplied by 1, the product is 1 larger than the number.
   e) When the same number is added to both terms of a ratio, the value of the ratio is increased. The reverse is true when the same number is subtracted from both terms.
   f) When zero is added to a number, the answer is the same as it would be if zero had been subtracted from the number.

In general, observation, discussion, and interview serve better than paper-and-pencil tests in evaluating a pupil's ability to understand the principles and procedures he uses in computation. Paper-and-pencil tests have their special functions and values. They readily yield a mark or a score, as for example, 60 or 85 on the percentage scale and "D" or "C" on a letter scale. These marks or scores mean something to the one who gives them and they are also understood by other teachers and supervisors. On the other hand, the teacher who works closely with his pupils should be able to form judgments of their understanding of computations that are fully as reliable as are the scores obtained from written tests. Furthermore, the teacher's judgment may be recorded by the use of letters, as for example, "E" for excellent, "S" for satisfactory, and "U" for unsatisfactory. All of our evaluation procedures are based upon sampling. They require a rich background in mathematics on the part of the teacher if understanding as well as mechanical skill in computations is to be evaluated.

Mathematical Understandings

Teachers generally are not as familiar with tests of mathematical understanding as they are with tests of computation and problem solving. Tests in the realm of *understanding* may be constructed so that they measure degrees of understanding and hence are useful for diagnostic purposes. Unfortunately, space does not permit the presentation of more than a sampling. These sample items will suggest both

(*a*) types of items that can be used and (*b*) the range of materials that can be covered.

The following items have been constructed so that they may be used in paper-and-pencil tests for groups of pupils. In general, the smaller the group of pupils to which a test is given, the more valuable are the test results if the teacher observes the pupils while at work. If possible, a simple interview afterward will enable the teacher to discover *why* a pupil rejects some answers and why he finally selects what he considers the correct answer to a test item. The point of departure in reteaching is then clear.

Understandings Developed from Computations. The exercises below illustrate a method of extending understandings beyond abstract computations, and then of measuring them.

1. Work the following examples.

a)	*b*)	*c*)	*d*)	*e*)	*f*)	*g*)	*h*)
3.4	3.4	9.6	9.6	9.6	.75	.75	.75
× 8	× .8	×.35	×3.5	× 35	× 9	× .9	×.90

2. Questions for discussion after the pupils have worked the examples.
   a) In which of the examples are the multipliers larger than 1?
   b) Are the products for examples (*a*), (*d*), (*e*), (*f*), and (*h*) larger or smaller than the multiplicands?
   c) Which of the examples have multipliers of less than 1?
   d) Are the products for examples (*b*), (*c*), and (*g*) larger or smaller than the multiplicands?
   e) Which word (*larger* or *smaller*) belongs in each blank in the following statement?
   When the multiplier is less than 1, the product is __________ than the multiplicand. When the multiplier is more than 1, the product is __________ than the multiplicand.

Meanings of Whole Numbers. The exercises in this and subsequent sections have been taken from longer and more complete tests. The original item numbers have been retained so that the reader may see that greater comprehensiveness and finer gradation are represented in the complete test. Directions are here omitted. The items are "multiple choice."

2. Which of the following numbers is smaller than 800?
   a) 867 *b*) 799 *c*) 820 *d*) 900
5. Which of the following numbers equals 5 hundreds, 4 tens, and 6 ones?
   a) 645 *b*) 456 *c*) 564 *d*) 546
9. When we count forward by 1's, what number comes next after 399?
   a) 490 *b*) 409 *c*) 400 *d*) 401

13. Which of the following numbers has a 9 in thousands' place?
    a) 6790 *b*) 5409 *c*) 9005 *d*) 7906
18. What number is 100 smaller than 7008?
    a) 6908 *b*) 7098 *c*) 7007 *d*) 6008

Meanings of Processes with Whole Numbers. The following are suited for Grades IVA to VA.

1. Three facts are given in the box. Which of the following belongs with the facts in the box?

   $$\boxed{\begin{array}{r} 3 \times 9 = 27 \\ 9 \times 3 = 27 \\ 27 \div 9 = 3 \end{array}}$$

   a) $9 + 3 = 12$ *b*) $27 \div 3 = 9$
   c) $27 - 3 = 24$ *d*) $9 \div 3 = 3$

3. Which of these examples is written correctly for subtracting?

   a) $\begin{array}{r} 437 \\ -900 \\ \hline \end{array}$ *b*) $\begin{array}{r} 294 \\ -76 \\ \hline \end{array}$ *c*) $\begin{array}{r} 243 \\ -\ 89 \\ \hline \end{array}$ *d*) $\begin{array}{r} 427 \\ -\ 8 \\ \hline \end{array}$

10. Which of these examples will have the same answer as the example in the box?

    $\boxed{\tfrac{1}{3} \text{ of } 27}$

    a) $\begin{array}{r} 27 \\ -\ 3 \\ \hline \end{array}$ *b*) $\begin{array}{r} 27 \\ +\ 3 \\ \hline \end{array}$ *c*) $3\overline{)27}$ *d*) $\begin{array}{r} 27 \\ \times\ 3 \\ \hline \end{array}$

The following exercises are suited for Grades VA to VIA.

1. In the example at the right, the first figure in the answer will be placed over which figure in the dividend?

   $\boxed{58\overline{)2697}}$

   a) 2 *b*) 6 *c*) 9 *d*) 7

2. What is the next step to take in the example at the right?

   $$\boxed{\begin{array}{r} 2 \\ 43\overline{)8975} \\ 86 \\ \hline 37 \end{array}}$$

   a) Bring down the 5
   b) Write 0 in the quotient over the 7
   c) Divide 43 by 37
   d) Multiply 43 by 2

8. Which of these examples is *wrong* because the quotient figure is too large?

   a) $\begin{array}{r} 3 \\ 43\overline{)159} \\ 129 \\ \hline \end{array}$ *b*) $\begin{array}{r} 6 \\ 23\overline{)118} \\ 138 \\ \hline \end{array}$ *c*) $\begin{array}{r} 4 \\ 51\overline{)218} \\ 204 \\ \hline \end{array}$ *d*) $\begin{array}{r} 5 \\ 62\overline{)342} \\ 310 \\ \hline \end{array}$

Generalizations with Whole Numbers. In the first three exercises choose the correct figures from the box at the right. Insert the figures in the blanks.

$$\boxed{\begin{array}{c} 0 \\ 1 \\ 5 \\ 9 \end{array}}$$

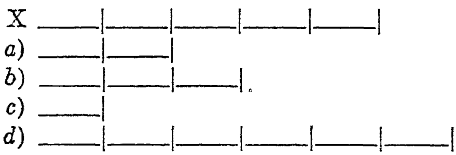
2. The quotient of any number divided by itself equals ______.
6. When any whole number is multiplied by 5, the product will have ______ or ______ in ones' place.
11. In a division example, if we cannot divide after we have brought down a figure, we place a ______ in the quotient.
18. In a division example, if a remainder is equal to or larger than the divisor, the quotient figure is ______.

   a) the right one b) too large c) too small
21. Without dividing, tell which of these examples will have the largest quotient.

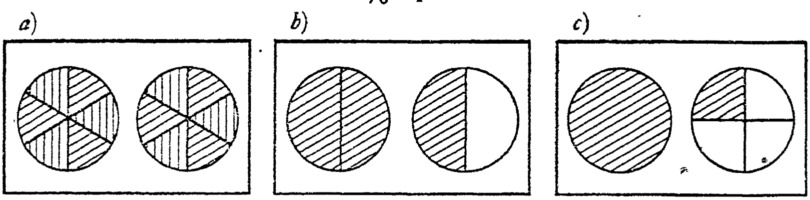
   a) $82\overline{)4136}$ b) $69\overline{)4136}$ c) $71\overline{)4136}$ d) $80\overline{)4136}$

Recognizing Fractional Parts. Draw a circle around the letter (*a*, *b*, *c*, or *d*) which indicates the correct answer to each question.

10. Which line below is $\frac{3}{5}$ as long as line X?

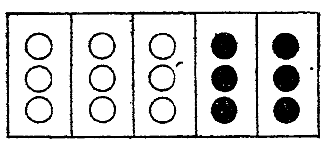


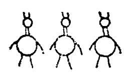
16. Which box below shows that $\frac{12}{6}$ equals 2 wholes?



18. What part of the dots in the rectangle is black?

   a) $\frac{2}{3}$ b) $\frac{3}{4}$ c) $\frac{2}{5}$ d) $\frac{3}{5}$



24. These are Mary's dolls:  These are Jane's dolls: 

   What part of all the dolls belongs to Mary?

   a) $\frac{1}{2}$ b) $\frac{2}{3}$ c) $\frac{2}{5}$ d) $\frac{1}{3}$

Meanings of Fractions. The following examples are suitable for Grades I-IV.

2. Jane's mother cut a pie into six equal pieces. She gave Jane a piece to eat. What part of the whole pie did Jane eat?

   a) $\frac{1}{4}$ b) $\frac{1}{6}$ c) $\frac{1}{5}$ d) $\frac{5}{6}$

3. Which of the following pieces of ribbon is shortest?

   a) $\frac{1}{8}$ yd. *b*) $\frac{1}{6}$ yd. *c*) $\frac{1}{4}$ yd. *d*) $\frac{1}{3}$ yd.

7. Helen wanted to give three-eighths of a cake to her sister. Into how many equal pieces should she first cut the cake?

   a) 3 *b*) 5 *c*) 8 *d*) 11

Technical Terms and Generalizations for Fractions. In the following exercises more than one answer may be correct or true. Pick out all the correct answers.

5. In which of the following groups are the fractions *like* or similar fractions?

   a) $\frac{1}{8}, \frac{5}{8}, \frac{7}{8}$ *b*) $\frac{3}{4}, \frac{3}{5}, \frac{3}{8}$ *c*) $\frac{3}{4}, \frac{5}{6}, \frac{7}{8}$ *d*) $\frac{3}{10}, \frac{7}{10}, \frac{9}{10}$

6. In which of these examples can one of the given denominators be used as the common denominator?

   a) $\frac{3}{4} + \frac{5}{6} + \frac{7}{12}$ *b*) $\frac{1}{2} + \frac{1}{3} + \frac{1}{4}$

   c) $\frac{1}{5} + \frac{1}{2} + \frac{1}{10}$ *d*) $\frac{3}{8} + \frac{2}{3} + \frac{1}{2}$

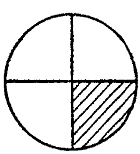
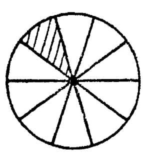
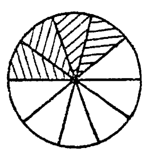
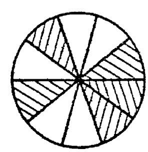
11. Which of the following are true?

   a) $\frac{3}{4} = \frac{3 + 4}{4 + 4}$ *b*) $\frac{3}{4} = \frac{3 \times 2}{4 \times 2}$

   c) $\frac{3}{4} = \frac{3 - 2}{4 - 2}$ *d*) $\frac{3}{4} = \frac{3 \times 5}{4 \times 5}$

Meanings of Decimal Fractions. Draw a line through the letter (*a, b, c,* or *d*) which indicates the correct answer to each question.

2. In which circle below is .4 shaded?

a)

b)

c)

d)


10. The decimals in the box at the right are supposed to be arranged in order of size from the largest to the smallest. One of the decimals is out of place. Which one is out of place?

(*a*)	2.9
(*b*)	1.3
(*c*)	.9
(*d*)	.058
(*e*)	.71
(*f*)	.1

15. The mixed number 6 $\frac{3}{100}$ equals which decimal below?

a) 6.3 *b*) 6.03 *c*) .63 *d*) 603

Meanings of Processes with Decimals.

1. Which of the following *is not* written in correct form for adding?

a) 3.50	*b*) .48	*c*) 2.0	*d*) 4.98
2.17	59.6	7.2	.67
.85	45	6.9	.08
6.90	9.3	.8	9.00

6. Study the example in the box at the right. What must the divisor .9 be multiplied by to make it a whole number?

$\boxed{.9\overline{)\,2.826}}$

a) by 100 *b*) by 10 *c*) by 1 *d*) by 1000

10. Which of the following examples will have the same answer as the example in the box?

$\boxed{1.2\overline{)\,9.6}}$

a) $.12\overline{)\,9.6}$ *b*) $12\overline{)\,9.6}$ *c*) $12\overline{)\,96}$ *d*) $1.2\overline{)\,.96}$

Generalizations with Common and Decimal Fractions. In the blank space at the end of each numbered statement write the letter (*a*, *b*, *c*, or *d*) which indicates the correct way to complete the sentence.

2. If the numerator and the denominator of a fraction are the same, the value of the fraction is ________.

a) greater than 1 *b*) less than 1 *c*) equal to 1 *d*) cannot tell

4. Multiplying the numerator and denominator of a fraction by the same number ________.

a) increases the value of the fraction.
b) decreases the value of the fraction.
c) does not change the value of the fraction.

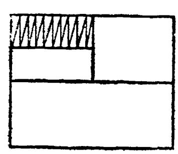
9. Moving the decimal point in a number two places to the left ________.

a) divides the number by 100
b) divides the number by 10
c) does not change the value of the number
d) multiplies the number by 100

11. In a division example, multiplying both the dividend and the divisor by the same number ________.

a) increases the quotient
b) decreases the quotient
c) leaves the quotient the same

Meanings of Per Cents.



4. What per cent of the picture is shaded?

a) $\frac{1}{8}$% *b*) 1% *c*) 12$\frac{1}{2}$% *d*) 100%

7. Every one of the pupils in Tom's room gave to the Junior Red Cross. What per cent of the pupils gave to the Junior Red Cross?

   a) 1% *b*) 10% *c*) 100% *d*) cannot tell

12. George weighs 150% as much as Tom. George's weight is how many times as much as Tom's weight?

    a) 1½ *b*) ½ *c*) 15 *d*) 150

Meanings of Processes with Per Cents.

13. Which of the examples in the boxes would you work to answer the questions below the boxes?

a) $28 + 12	*b*) $28\overline{)12.00}$	*c*) $.28\overline{)12.00}$	*d*) $12\overline{)28}$	*e*) $12 × .28

(1) What does 28% of $12 equal?
(2) $12 is what per cent of $28?

16. When we find 105% of $80, the answer will be ________.
    (Choose the answer to fill the blank from the statements below.)

    a) larger than $80 *b*) smaller than $80
    c) exactly $80 *d*) there is no exact answer

24. In making candy, Jean used 3 cups of white sugar and 1 cup of brown sugar. What per cent of the sugar was brown?

    a) 33⅓% *b*) 25% *c*) 66⅔% *d*) 50%

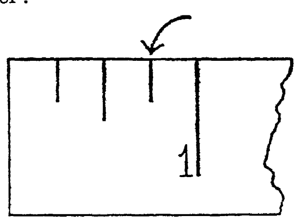
Meanings and Uses of Measures.

1. If you measured the length of a table, with which of the following units of measure would you get the largest number?

   a) inch *b*) foot *c*) yard *d*) mile

5. At the right, a part of a ruler is pictured. The arrow points to what measure on the ruler?

   a) ½ in. *b*) ¾ in. *c*) ⅜ in.
   d) none of the preceding answers.



9. Which of the following fractions of an hour is most difficult to find on a clock by noting the minute hand?

   a) ⅓ hr. *b*) ¼ hr. *c*) ⅕ hr. *d*) ⅛ hr.

13. A meter stick equals 39.37 inches. A centimeter is a hundredth part of a meter. To the nearest tenth inch, how long is a centimeter?

    a) 39.4 in. *b*) 3.9 in. *c*) .4 in.
    d) cannot tell from the information given above.

Mathematical Understandings in Social Situations

Here we are concerned with the measurement of a pupil's sensitivity to number in social situations and with his habit of using numbers effectively in such situations. Formal tests reveal only a portion of a pupil's ability and desire to use his mathematical information in social and economic situations. The ideal way to judge a pupil's sensitivity to mathematics is through observation of his behavior as he proceeds normally in his accustomed environment.

For example, Kenneth was telling his playmate about some cats in the neighborhood and remarked that Blackie was about a third as big as Ginger and that Fluff was about two-thirds as big as Ginger. When Kenneth was interviewed it was discovered that he used "one-third" for anything less than half and "two-thirds" for fractional parts larger than half. He was seven years old at the time. Further investigation revealed that he had heard his father using "thirds" but had had no explanation thereof. When he was given a mathematical explanation of "thirds" he easily grasped the idea and asked if there were "fourths" and other fractions. Kenneth was sensitive to mathematics.

Unfortunately it is difficult for a teacher to observe many children in their natural out-of-school habitats. However, school situations are available to the teacher who is looking for them and knows how to capitalize upon them. A fourth grade was planning for a Valentine box. How big should it be? Pupils showed with their hands their ideas of size for the box. Two girls were to get a box of about the right size. One pupil suggested writing down the measurements. The teacher had each pupil write down his estimate of the length, width, and height. Then measurements were made of the size shown by one of the pupils with his hands. Estimates were compared to measurements. Other estimates and judgments were made by the pupils when the box was decorated and a slot cut in the top. Thus, this teacher in many ways appraised her pupil's sensitivity to and judgment about mathematical relationships.

Written tests are particularly useful in measuring pupils' abilities to use mathematics if the testing is followed by discussion. The test then serves as a step in teaching as well as a measuring instrument. The following sets of exercises of the "multiple choice" type are suggestive.

Knowledge of Vocabulary of Quantitative Terms.

1. **Mary read that New York is the largest city in the United States. What does "largest city" mean?**

a) has the tallest buildings *b*) has the most people
c) has the most land *d*) is worth the most money

2. Peter said, "It is a very hot day." How warm is "very hot"?
   a) 90° *b*) 68° *c*) 120° *d*) cannot tell exactly

3. The local newspaper reported that the city had balanced its budget. What is meant by "balanced budget"?
   a) has collected all debts *b*) is starting a new year
   c) has an income equal to expenses *d*) has lowered expenses

4. What do we call the money one pays for protection on an insurance policy?
   a) premium *b*) dividend *c*) discount *d*) commission

Knowledge of Business Practices and Economic Uses.

1. For which of the following size packages of breakfast food would you expect the price per pound to be lowest?
   a) 12 ounces *b*) 1½ pounds *c*) 5 pounds
   d) the price per pound is always the same for all sizes

2. Last year there was a large crop of potatoes and this year there is only a small crop. How would you expect the price this year to compare to price last year?
   a) the same *b*) less this year *c*) more this year

3. The P.-T.A. held a food sale. In order to find the net profit from the sale, which of the following do they need to know? (Select all the answers needed.)
   a) the total amount of money taken in
   b) the total number of people who bought things
   c) the total cost of the foods
   d) the total number of things given to the P.-T.A.

4. When eggs sell for 50¢ per dozen at the place where they are produced, what is likely to be the price in a city 150 miles away?
   a) 48¢ *b*) 50¢ *c*) 58¢ *d*) $1.50

Interpretation of Data Presented Graphically and in Tables.

1. According to the chart, which food changed most in price?

Year	Price of Foods			
	Eggs	Bread	Milk	Roast
Last year	$0.48	$0.11	$0.13	$0.39
This year	0.51	0.11	0.11	0.43

   a) eggs *b*) bread *c*) milk *d*) roast

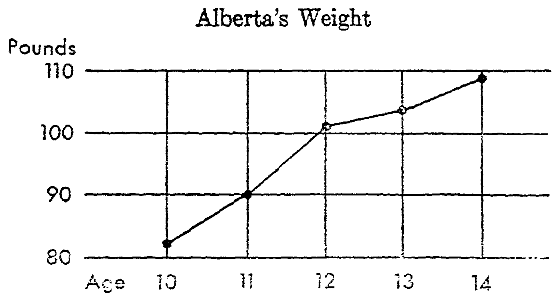
2. If the prices in the chart above are considered a fair sample of the cost of living, how does the cost this year compare to the cost last year?
   a) the same *b*) less *c*) more *d*) cannot tell

3. In social studies we have made a line along which we will arrange dates in history. The line begins with the year 1700 and ends at 2000. What letter on the line is at the year 1812?

   a) A *b*) B *c*) C *d*) D

4. Study the graph of Alberta's weight. During what year did she gain most in weight?

   a) 10 to 11
   b) 11 to 12
   c) 12 to 13
   d) 13 to 14



5. How old was Alberta when she weighed approximately 100 pounds?

   a) 11 yr. *b*) nearly 12 *c*) exactly 12 *d*) a little more than 12

Usefulness of Quantity in Many Aspects of Life.

1. In which of the following tasks of a nurse is arithmetic used? (Select all correct answers from the list.)

   a) taking and recording temperatures
   b) bathing a patient
   c) mixing medicines and solutions
   d) making beds

2. In taking and recording a pulse rate which of the following are used? (More than one answer may be correct.)

   a) counting *b*) reading Roman numerals *c*) weighing
   d) making a chart or graph

3. How many days are included from the tenth of one month to the tenth of the following month?

   a) 28 days *b*) 30 days *c*) 31 days
   d) it depends upon which months are used

Using Number in Normal and Vicarious Experience: Judgments.

1. Johnny, aged 6, said, "My father makes millions of dollars." Which statement below is probably true?

   a) His father is a counterfeiter.
   b) Johnny doesn't know how much a million is.
   c) His father works in the U.S. mint.
   d) Johnny saw his father counting a million dollars.

2. Julia has a "7-day book" from the library. It has 300 pages. She read 100 pages the first day. To finish within the 7-day limit she
   a) might continue at the same reading rate.
   b) must read an average of 50 pages per day.
   c) should take the book back immediately.
   d) must read the remainder at the rate of $42\frac{6}{7}$ pages per day.
3. The Carlson family was planning to visit their uncle George. In deciding whether to go by bus or by car, which one of the following is *least* important to consider?
   a) Cost of bus fare compared to expense by their own car.
   b) Time schedule of bus.
   c) Number of people in the Carlson family.
   d) Uncle George was president of the bank.
4. To walk a half mile without dawdling would take about
   a) 2 min. *b*) 5 min. *c*) 10 min. *d*) 20 min.
5. If you wished to help in building a small table quickly, how many people would you ask to help you?
   a) 1 person *b*) 6 people *c*) 12 people *d*) 50 people
6. If you were planning to serve lemonade to a class of 35 children, about how much should you provide?
   a) 1 gal. *b*) 3 gal. *c*) 8 gal. *d*) 25 gal.

Disposition to Extend One's Sensitiveness to the Quantitative. Many alert observers have noted how young children are sensitive to size, shape, weight, surface, and quantity. Early impressions are combinations of manual and visual avenues of learning. They are experimental and tend to imply increasing degrees of organization. An experimental procedure seems best adapted for evaluation in this realm, especially with young children. Several illustrations follow.

1. Tracy, aged 5, was given some metal soldiers. He arranged two armies of about equal number. Then he was observed trading soldiers from one army to the other. His trading involved exchange of two small soldiers for one large one. Finally he was ready for battle with almost equal strength in each army. He was sensitive to both size and quantity.
2. Donna, aged 6, opened the drawer of playthings and took out a box of blocks and a box of marbles. She did a little experimental building, discovered that cylindrical blocks had to stand a certain way, that marbles would not stay on top of blocks, and developed a crude sense of "center of gravity." After a time she quit building and sorted the blocks by size and shape. When she started arranging marbles, she made several experimental attempts, based apparently on color and size. She put two steel marbles off to one side. The observer, on questioning, learned that Donna had considered the factor of weight.

3. Lawrence, aged 7, came to an observer in his room and said, "Can I ask you a question?" He then asked, "How much is six times four?" He was given the answer, 24. Later he asked, "How much is four times six?" Instead of supplying the answer the observer showed him how to make four piles of six books and how to get the answer to his question. Incidentally the meaning of the question was also demonstrated. Lawrence, with a little help, developed "six times four" with piles of books. That evening, when his mother returned from work, she found Lawrence with dominoes on the table. He said to his mother, "We haven't got many books; don't touch the dominoes." After dinner he said to his father, "Dad, now you ask me 'times anything'; just ask me times anything." The father asked several questions and the boy proceeded to arrange dominoes and get the right answers. The climax came when Lawrence discovered that $6 \times 5 = 5 \times 6$ and exclaimed: "Jimminy Jeepers! the same 30."
4. Alice, in grade five, beamed with a discovery. She had been doing long division. Impatiently, she told her teacher, "When the remainder is small, the next answer number is small, and when the remainder is large the next answer number is an eight or a nine."

Summary and Final Statement

Attention has been directed toward two general methods of evaluating understandings in elementary-school mathematics (1) by use of paper-and-pencil exercises and (2) by observation, discussion, and interview. Usually it is most fruitful to combine both methods for comprehensive evaluation. A thorough knowledge of the nature of mathematical learning, particularly of *understanding* and *meaning*, enables a teacher to determine when one technique of testing is superior to another.

Teachers are counseled to observe and to discuss with their pupils the developmental and understanding phases of mathematics. Furthermore, the well-trained and experienced teacher should give marks or scores on these phases of mathematics just as he does on abstract computations. Usually it is found that pupils who have not developed meanings and understandings as they are learning mathematics do not learn to compute well and do not sense the essential mathematics in a social or economic situation.

The measurement of *meanings* and *understandings* is beginning to creep into research in arithmetic. Of twenty-seven studies examined, eight showed that the author was deliberately trying to measure beyond the traditional scope of computations and problem solving. New procedures in teaching and evaluation will need to be developed as the schools broaden their vision of the function and scope of mathematics.

CHAPTER VIII

THE MEASUREMENT OF UNDERSTANDING IN SECONDARY-SCHOOL MATHEMATICS

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OBJECTIVES

The most authoritative modern statement of the objectives of mathematical instruction at the secondary level is doubtless to be found in the Final Report of the Joint Commission of the Mathematical Association of America and the National Council of Teachers of Mathematics (**8**). In this formulation the specific objectives are grouped under seven major headings as follows:

I. The field of number and of computation
II. The field of geometric form and of space perception
III. The field of graphic representation
IV. The field of elementary analysis
V. The field of logical (or "straight") thinking
VI. The field of relational thinking
VII. The field of symbolic representation and thinking

Within these groups the objectives are further classified in terms of several different types of behavior. One of these types is concerned with the acquisition of basic concepts and principles, another is concerned with the development of fundamental skills, and a third includes the ability to make application of facts, concepts, and principles in practical situations.

In the present discussion, emphasis is placed on the *understanding* of basic concepts and principles. The objectives and measurement techniques relating primarily to fundamental skills and processes fall

outside the scope of the yearbook. Since the ability to *apply* is closely related to any reasonably satisfactory notion of understanding, this ability is discussed from the point of view of evidence of understanding. Certain other types of objectives discussed by the Commission, such as the development of desirable attitudes, interests, and appreciations, are important but cannot be considered here.

A discussion of an objective as broad as "the understanding of concepts" usually necessitates some ranking or weighting of the concepts themselves. Consider, for example, the concept of *ratio* and the concept of *proof*. It is useless to try to decide which is more "basic" or "fundamental." It is, however, easy to recognize that ratio is a relatively simple notion, while proof involves a number of subconcepts and abilities. The report of the Joint Commission met this difficulty by selecting for separate treatment in the major *fields* V, VI, and VII certain comprehensive notions and abilities which might have been denoted by terms like proof, relation, and symbolism. The discussion which follows will also pay special attention to these particular major fields or concepts.

The objective relating to basic *concepts* of the less complex sort will be given first, and six subtypes of behavior which reveal understanding will be listed. This analysis is applicable to concepts from any of the seven major fields mentioned above. Objectives which depend upon the understanding of fundamental *principles* relating to fields V, VI, and VII will next be considered. Statements of the principles themselves will appear later in connection with evaluation techniques. Third, the objective relating to *practical application* will be explained and discussed briefly.

Understanding of Basic Concepts

"A clear understanding of the meaning of the basic terms and the ability to recognize their actual occurrences and their bearings in life situations. Examples of such concepts are: assumption or postulate, proposition, converse, conclusion."[1] Evidence of this understanding may be given by:

a) Associating a word with an example.
b) Providing an example to illustrate a term.
c) Developing a formal definition of a basic term.
d) Indicating, by means of a diagram, an example, or a statement, a knowledge of the meaning of a word presented *in context*.

[1] The wording of the objectives relating to basic concepts and principles by the Commission (8: 66-67) varies somewhat from field to field. The quotation is from Field V.

e) Associating a word with a situation in which the figure, relation, operation, etc., it represents or symbolizes might be used.
f) Recognizing the misuse of a word in context.[2]

Understanding of Fundamental Principles

In connection with the Field of Logical Thinking:

"A clear grasp and appreciation of the assumptions and principles on which the structure of mathematics rests. This involves considerations such as the following:

a) "A knowledge of the principles underlying the manipulative techniques of mathematics, such as those relating to order, grouping, distribution, and the like.
b) "The realization of the logical implications of related propositions, such as those involving a given theorem, its converse, its opposite.
c) "The realization of the economy resulting from such an organizing principle or assumption as that of continuity."

Such abilities as the following should be gradually developed:

d) "To recognize and formulate the assumptions underlying an argument.
e) "To recognize terms that require precise definition.
f) "To organize statements in a coherent logical sequence."[3]

In connection with the Field of Relational Thinking:

g) The ability to recognize relationships between variables.
h) The ability to interpret relationships expressed in symbolic form, including representation in the form of tables, graphs, formulas, and verbal statements.[4]

In connection with the Field of Symbolic Thinking:

i) "An appreciation of the economy and the power resulting from the correct use of symbolic techniques" (8: 68).

Understandings Involved in Practical Applications

"The ability to recognize and use arithmetical facts, concepts, and principles in everyday life situations" (8: 62).

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[2] The first three of these six subtypes of behavior are explicitly mentioned by the Commission (8: 62-68). The last three types of behavior usually involve more complete understanding than do the first three (5).

[3] Following this, the Commission (8: 67) listed three additional abilities not entirely distinct from the first three. They are omitted here because of limitation of space. For discussion and illustrative measurement devices, consult (3, 7, 9).

[4] Objectives (*g*) and (*h*) are typical of statements found in various sources (4, 8, 10).

The report of the Joint Commission mentions practical application in connection with each field, but does not elaborate. The quoted statement was made in connection with the field of number and of computation, and there is emphasis of the same sort in connection with the fields of logical and relational thinking. The ability to make applications may or may not involve much understanding of fundamental principles or basic concepts. For example, some people learn to use a slide rule (or other computing devices) with little or no understanding of why it produces results. They only know *how* to use it and that "it works." If, however, in making the application there is evidence that the appropriate concepts, principles, and related subabilities are consciously associated with the situation, the successful application provides a highly desirable form of evidence of the understanding. Therefore, in the measurement of the ability to apply, the understanding of principles and concepts may be inferred when the technique insures the association or provides supplementary evidence showing that the appropriate concepts and principles are related to the operation, conclusion, or solution which resolved the problem.

It should be obvious that the illustrative evaluation devices which follow can only serve to help show that evaluation of understanding calls for something in addition to the usual testing techniques. The evaluation need not be elaborate and formal, but it should stem from a careful analysis of what is wanted. Although it should be as direct and simple as possible, it must dig into essential elements.

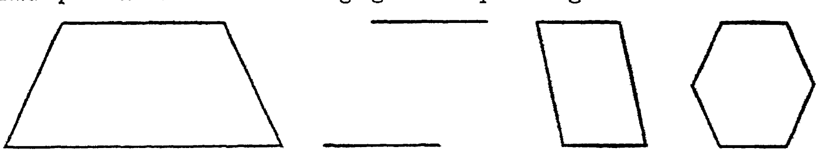
Examples of Techniques

In the following pages a variety of techniques for obtaining evidence of understanding are suggested and, in some cases, briefly discussed. The examples are paired with the objectives listed above, and for easy reference the same numbering is used here.

Understanding of Basic Concepts

a) Association of a word with an example of the class that the word denotes. The familiar "multiple-choice" or "completion" testing techniques, in which a group of geometric figures or algebraic expressions is given and the pupil is asked to identify a particular one by name, are well suited to the measurement of this behavior (**5**).

Example: Which of the following figures is a parallelogram?



(1) (2) (3) (4)

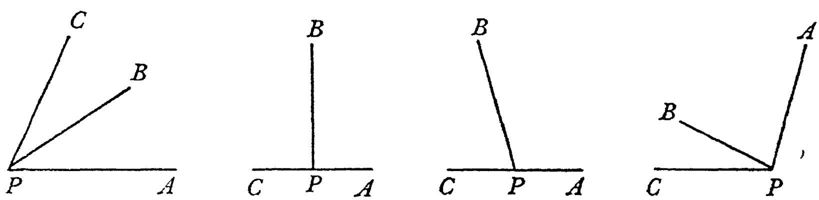
Example: Which of the following expressions is a binomial?

$$(1)\ p-3q;\quad (2)\ x^2;\quad (3)\ \frac{a+b}{c};\quad (4)\ x^2+2xy+y^2$$

b) *Providing an example to illustrate a term.* The direct technique of giving a list of terms and asking the student to give examples is obviously suitable.

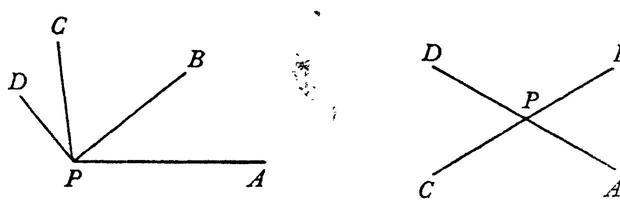
c) *Developing a formal definition of a term.*[5] No easily applicable testing technique is suitable for this objective. Evidence of achievement may be secured by repeatedly observing and recording the performance of individuals during discussions of new concepts. Or, more formally, the teacher may approach the new concept by a relatively strict adherence to the inductive method, discouraging *oral* generalizations or definitions, but encouraging comparisons between examples as well as the formulation and revision of *written* definitions by each member of the group as the presentation proceeds. The written definitions may then be collected and evaluated later.

Example: Present (on the blackboard or on paper by duplicating machine) several figures illustrating adjacent angles in different positions.



(i) In each figure, angles *APB* and *BPC* are called adjacent angles. Write a definition which will apply to all of these figures.

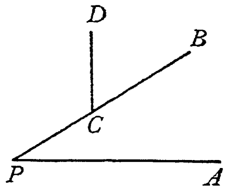
(ii) Does your definition also apply to angles *APB* and *CPD* in the figures below?

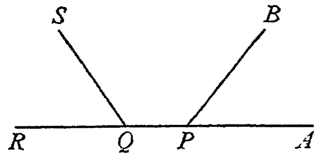


If it does, it is not good, for usually $\angle APB$ and $\angle CPD$ are not called adjacent angles. Revise your definition so that it does not apply to these angles.

[5] It is important to recognize that this behavior is not the same as giving, or recalling, a previously learned definition.

(iii) Does your definition also apply to angles APB and BCD below? To angles APB and RQS?





If it does, it is not good, for usually these are not called adjacent angles. Change your definition so that it does not apply to these two figures. Now read your definition again and make sure it covers the first four of these figures and does not cover the last four.

d) Indicating by means of a diagram, an example, or a statement, a knowledge of the meaning of a word presented in context.

Example: In the paragraphs of the test certain words are *underlined.* These same words appear in the same order on your answer sheet. First, read the paragraphs. Next, write on your answer sheet the meaning of each word as it is used in the reading materials. You may draw a diagram, give an example, describe a situation, or write a sentence in order to show the meaning which you give the word. Give the meaning which the word has for you in the sentence in which it appears.

"John wished to make a scale drawing of the airplane which he was studying. The length of the wing spread was 77 feet. He found it necessary to represent this by 11 inches on his drawing. From this he figured the ratio of the length in the airplane to length in the drawing. Part of the work of making the drawing required a knowledge of how to reduce a fraction."[6] (A separate answer sheet, containing a list of the underlined terms and spaces for the responses, may be provided.)

e) Associating a word with a situation in which the figure, relation, operation, etc., it represents might be used.

Example: Which of the following sentences describes a situation in which the word "quadratic" would be used?

(1) The second term in the equation contained the unknown.
(2) The equation which was necessary used the second power of the unknown, but higher powers were not needed.
(3) Tom found that the use of an equation gave him greater power.
(4) The fifth exercise was the most difficult equation in the whole list.
(5) In none of these situations would "quadratic" be used.[7]

[6] Thomas Hastings, "The Evaluation of Techniques for Testing Mathematical Concepts," Form D. Unpublished master's thesis, Department of Education, University of Chicago, 1940.

[7] These directions and test items are adapted from those used by Hastings, *Op. cit.,* Form E, p. 1. His complete test covered thirty-five terms, and rather than repeat the question and sentences each time, he included them in his general directions to the student.

f) Recognizing the misuse of a word in context. Each of the following selections is about some mathematical situation. The activities described and the numbers used are correct, but in some cases the wrong term (mathematical word) is used. You are to read the selections and underline the terms which you believe have been used incorrectly.

Illustration: In a problem which John was working it was necessary to add 618, 431, and 215. He added them and found their product was 1164. He checked by adding them over. (The word *product* was underlined in this selection. When numbers are added, their sum, not their product, is found. *Product* was used incorrectly.)

Example: In making arrangements to redecorate his home, Mr. Gray found that he needed to use some mathematics. The ratio between the height, 12 ft., and the width, 10 ft., of a certain room was 2 ft. It was also necessary to find the area of the air in the room for purposes of heating. To solve the problem of lighting the room, Mr. Gray had to determine certain angles formed by lines drawn from various points in the room to the center of each window.

Example: In the equation $2xy = 32$, the exponent, x, represents velocity, and y represents time. The root of the equation is the time-rate-distance formula, $d = vt$.[8]

An informal modification of the preceding technique may be used to good effect. At the beginning of certain new units (e.g., in informal geometry) prepare with the students a list of mathematical terms which they think will be involved. Encourage them to write sentences, paragraphs, short essays, playlets, poems, or cartoons in which some of the terms are used in context. It will ordinarily be found that a considerable number of the terms are used incorrectly. This fact should be deliberately overlooked until the end of the unit, at which time selections from the students' products can be duplicated and the technique described above employed. Discussion of the results with the class can bring out the growth in understanding of the *mathematical* meaning which has resulted from the unit.

Understanding of Fundamental Principles

For the Field of Logical Thinking:

a) Principles underlying the manipulative techniques of mathematics.

First, in preparing test items, try to modify the conventional forms of presenting exercise material so that rote learning is less likely to provide successful responses and that more thorough understanding of principles is rewarded (6).

[8] **Hastings,** *op cit.,* Form F, p. 1.

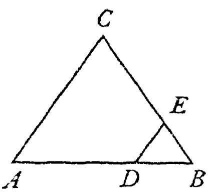
Example:

Conventional:

(i) Add $\frac{m}{x} + \frac{n}{2x}$

(ii) Solve for x: $3x + 2 = 536$.

(iii) In $\triangle$ ABC, DE // AC, and $\angle C = 35°$. How large is $\angle DEB$?



Modification:

(i) The fractions $\frac{m}{x}$ and $\frac{n}{2x}$ may be combined by addition into a single fraction expressed in lowest terms. What is the numerator of this fraction?

(ii) For what value of e does $3e + 2$ represent 536?

(iii) In a $\triangle$ ABC, $\angle C = 35°$; point D moves along AB but DE remains parallel to AC. Then $\angle DEB$:
(1) keeps getting smaller.
(2) keeps getting larger.
(3) remains the same size.
(4) is larger or smaller than 35°, depending upon where D is.

Although somewhat dependent upon verbal abilities, the device of asking students to state the situation in their own words provides evidence of understanding. They should, for example, be able to state the question which corresponds to the equation $3x + 2 = 536$ in some such form as follows: "What number, if it is multiplied by 3 and the result is increased by 2, gives 536?" Also, in example (iii) above, a student may be expected to say "ABC represents any triangle which has $\angle C = 35°$. DE represents a line parallel to AC. Then no matter where D is on AB, $\angle DEB = \angle ACB$."

Second, require an explicit indication of the association of principles with operations, and assign scoring values so that each principle correctly associated increases the score.[9] In the case of operations with equations, the association may be indicated by the student through the use of standard symbols adopted by the text or the class (e.g., M_2 for "multiplying both sides by 2"). However, this practice complicates scoring, since some students may use different methods and more steps than others. Moreover, in the case of many types of work other than equations, standard symbols are seldom used. Consequently, a slightly more formal method such as the following is recommended.

Example: In solving a problem a student substituted $\frac{7}{8}$ for $\frac{21a}{24a}$ Which of the following rules applies to this situation?

[9] This is a form of application, but it is at a theoretical rather than practical level.

A. If both numerator and denominator of a fraction are multiplied by the same number (not zero), the resulting fraction is equal to the original one.
B. If both the numerator and denominator of a fraction are divided by the same number (not zero), the resulting fraction is equal to the original one.
C. If the same number is added to both numerator and denominator of a fraction, the resulting fraction is *not* equal to the original.
D. If the same number is subtracted from both numerator and denominator of a fraction, the resulting fraction is *not* equal to the original.

If many exercises or items of similar type are to be given, the principles or rules need not be repeated with each exercise. They can be drawn together into a single list to which the student refers in connection with each problem.

Example: In the first column below is a list of algebraic expressions. Opposite each and in the second column is a new expression obtained from the original. (Pay no attention now to the column headed *Rule.*)

If the new expression is always *equal* to the original, put a check mark ($\surd$) in the third column. If the new expression is *not* always equal to the original, put a zero (0) in the third column.

Now fill in the column headed *Rule.*

Below is a list of rules or principles used in algebra. Put, in the parenthesis of the fourth column, the letter of the rule (*A*, *B*, etc.) which applies to each problem. If none of the rules seems to apply, leave the parenthesis blank.

List of Rules. (Here would appear statements of principles of the type illustrated by statements *A, B, C,* and *D,* in the previous example.)

	Original	*New*	*Put check* ($\surd$) *or* (0) *here:*	*Rule*
(1)	$\frac{21a}{24a}$	$\frac{7}{8}$	$\surd$	(B)
(2)	$\frac{a}{b}$	$\frac{a+x}{b+x}$	0	(C)
(3)	$\frac{a^2-b^2}{a-b}$	$a-b$	0	( )
(4)	$\frac{5}{x}$	$\frac{5y}{xy}$	$\surd$	(A)
(5)	$\frac{a+b}{a+c}$	$\frac{b}{c}$	0	(D)
(6)	$\frac{mr+ms}{nr+ns}$	$\frac{m}{n}$	$\surd$	(B)

In a complete test many more exercises of this sort may be given. It should be noted that in addition to indicating the principle used, the student is here asked to decide whether the old and new forms are equivalent.

This basic technique may be modified in various ways. For example, the third column (and the corresponding directions) may be omitted. Other rules or principles may be used, either in a new group or as additions to this list. The principles selected can be duplicated on a separate sheet of paper. This plan simplifies the appearance of the test, is more convenient, and permits the same sheet to be used with other tests. When employed with equations, a separate line should be used for each step of the solution shown. For the purpose of evaluating understanding it is not necessary that the complete solution be shown. One or two steps may be sufficient. As an additional modification, the student can be asked to indicate in another column the multiplier, divisor, etc., which has been used (e.g., in the first exercise in the preceding example the divisor used is $3a$.)

b) *Realization of the logical implications of related propositions, such as those involving a given theorem, its converse, its opposite.* List a number of simple propositions (i.e., only one hypothesis and one conclusion) and ask students to state the converse and the inverse for each. Provide spaces in which they can record their judgment of the truth or falsity of the various propositions. Study the *pattern* of responses, since the converse and the inverse are either both true or both false. (Illustration is here completed; only the propositions would be given.)

Statements	(Check one) True	False
Proposition: All elephants are large animals.............	√	
Converse: All large animals are elephants................		√
Inverse: All animals that are not elephants are not large..		√
Proposition: All triangles which have two equal sides have two equal angles..................................	√	
Converse: All triangles which have two equal angles have two equal sides....................................	√	
Inverse: All triangles which have no two sides equal have no two angles equal................................	√	

c) *Realization of the economy resulting from organizing principles.* E.g., "In introducing new numbers to the system, the rules for using

them are so chosen as to involve a minimum of modification or change in the existing set of rules."

Illustration. In algebra it is usually agreed that "the product of two negative numbers is a positive number, or $(-a)(-b) = +ab$." This agreement is: (check one)

_____ (1) absolutely necessary and also desirable.
_√__ (2) not necessary but desirable in order to be able to use, with signed numbers, most of the same rules as in ordinary arithmetic.
_____ (3) not necessary and not desirable because it makes algebra more difficult.
_____ (4) absolutely necessary but not desirable.

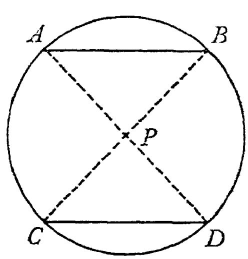
Illustration. In algebra it is usually agreed that $a^\circ = 1$. This agreement is: (check one)

_____ (1) absolutely necessary and also desirable.
_____ (2) not necessary and not desirable; it would be more sensible to agree that $a^\circ = 0$.
_√__ (3) not necessary but desirable in using the rules for exponents.
_____ (4) absolutely necessary but not desirable because it is confusing.

d) To recognize and formulate the assumptions underlying an argument. An associated *principle* may be stated as follows: If a conclusion follows logically from certain assumptions, then one must accept the conclusion or reject the assumptions.

In blackboard work students are usually expected to discover errors in the work of others. Such incorrect responses are, however, seldom used by teachers as material for a more formal evaluation, possibly because a written test is time-consuming to construct and is also space-consuming. However, if student papers which contain typical errors (as in the example below) are duplicated, a very discriminating testing device becomes available.

Example. This is the way one student gave the statements of a proof for an exercise in geometry.



Given data: In circle P, AB and CD are chords. $AB // CD$.
Conclusion: $AB = CD$.

Proof:

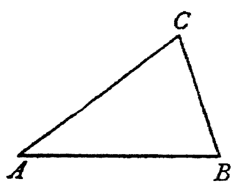
1. Draw radii PA, PB, PC, PD.
2. $PA = PB = PC = PD$.
3. $\angle APB = \angle CPD$.
4. $\therefore \triangle APB \cong \triangle CPD$.
5. $\therefore AB = CD$.

Do you accept the proof given in the above problem? Yes_____; No_____.
State below any assumptions made in the proof which you do not accept.

In a complete test some acceptable proofs should be mixed with unacceptable ones. The responses of the students do not need to be put on the same paper as the problems. A separate answer sheet may be provided, or students may use their own writing paper. In this way the same set of problems may be re-used with different sections or from year to year, and the device thus made quite practicable.

e) To recognize terms that require precise definition. Associated principles may be stated as follows: Crucial words and phrases must be precisely defined. A change in a definition may result in a change in the conclusion although the argument from each definition is logical. In situations in which precise definition is important, two or more conflicting interpretations may be set up and presented to the student as in the examples below.

Example.



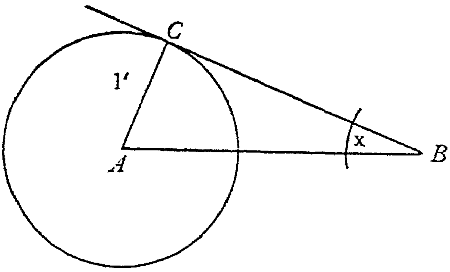
Triangle ABC is isosceles, with $AB = AC$.

Student X said: "$\angle A = \angle B$, because the base angles of an isosceles triangle are equal." Student Y said: "$\angle B = \angle C$, for the same reason." Student Z said: "Therefore, all three angles are equal, and the triangle should be equilateral."

Was the statement of Student X correct? Yes____; No____; Uncertain____.
Was the statement of Student Y correct? Yes____; No____; Uncertain____.
Was the statement of Student Z correct? Yes____; No____; Uncertain____.
If you think one or more of the statements is *not* correct, or if you are *uncertain*, state below what the trouble seems to be.[10]

[10] In some courses the term "base angle" as used by Student X, and similar difficulties, would be avoided. In the objective under consideration, however, the aim is to help the student recognize such possible sources of ambiguity when they are encountered—for example, in later courses, the shop, or the laboratory.

Example.



Looking at this figure, Student X said: "The tangent from B is BC." Student Y said: "The tangent is $1 \div BC$." Student Z said: "The tangent is $BC \div 1$."

Was the statement of Student X correct? Yes____; No____; Uncertain____.
Was the statement of Student Y correct? Yes____; No____; Uncertain____.
Was the statement of Student Z correct? Yes____; No____; Uncertain____.
If you think one or more of the statements is *not* correct, or if you are *uncertain,* state below what the trouble seems to be.

f) *To organize statements in a coherent logical sequence.* An associated principle may be stated as follows: A logical demonstration usually involves a chain of syllogisms.

The device of presenting the numbered statements of a proof in jumbled order and asking the students to organize them logically is sometimes used to measure achievement of this ability. The technique is complicated by the fact that several different orders or arrangements may be equally logical. Also, it may not provide a valid measure of the *understanding* that a formal logical demonstration (as in geometry) involves a chain of syllogisms. This understanding may be measured by adopting a scheme of notation which enables the students to identify elements in the proof. For example, P_1 for major premise 1, p_1 for minor premise 1; C_1 for conclusion 1; P_2 for major premise 2, etc. The statements and the reasons of the proof should be numbered, and these symbols placed in columns beside the numbers. The *pattern* of the responses must be studied. To avoid this and other difficulties in scoring arising from different methods of attack, some proofs may be duplicated and the students directed to mark in accordance with the scheme suggested. The remarks on practicality made in connection with (*d*) also apply here.

For the Field of Relational Thinking:

There is an extensive body of material now available on "functional thinking," including several published tests. It is not possible to give here an analysis of the numerous subconcepts and understandings involved (**4, 7, 10**) or to exhibit more than a few examples. For

purposes of illustration, suggestions will be given which involve ability to recognize and to interpret relationships.

g) *The ability to recognize relationships.* First, problem situations may be presented and the students asked to *list* factors on which the result depends.

Example: Bill has decided to ride his bicycle from his home to his grandmother's house in a nearby town. How long will it take him? List the things you need to know in order to answer this question.

Second, true or false statements of relationships may be formulated and presented in one of the usual forms.

Illustration. The longer you travel at a constant rate, the greater the distance that will be covered.......................................(T)

If an order is placed for "two kinds of candy which are to total 24 pounds," the clerk will know how many pounds of each kind to send....(F)

The area of a regular polygon can be found if the perimeter and number of sides is given...(T)

Third, either insufficient data or unneeded data may be systematically presented in problem situations, and papers scored on the ability of students to state what is needed or not needed.[11]

Example: In each of the following statements either too little information is given to justify the conclusion, or more than is needed is given. Rewrite each statement so that the information given is *just enough* to justify the conclusion.[12]

(1) If the angles of a triangle are in the ratio 1:2:3 and one of the angles is 30° more than another, the number of degrees in each angle can be determined.
(2) If the first term and the number of terms of an arithmetic progression are known, then the sum of the terms of the progression can be determined.
(3) If two circular disks of metal, each 1 inch in diameter and $\frac{1}{16}$ inch thick, are melted and made into a single circular disk of the same thickness, the ratio of the diameter of the new piece to the diameter of the original disks is $\sqrt{2}$: 1.

[11] Exercises of this kind may now be found in teaching materials, but the ability is seldom tested.

[12] These directions and the statements following them are taken, with slight adaptations, from recent New York Regents' examinations. It may be noted that, strictly speaking, the student should add phrases to make explicit certain implicit relationships (e.g., the sum of the angles of any triangle is 180°), as well as delete or add certain other items of data. This type of response does not seem to be expected, and the students' recognition of the role of the relationships must be inferred.

h) The ability to interpret relationships. Among the principles involved in the interpretation of relationships are the following:

Between any two given numbers there are many relations. For example, given the pair 24 and 3, among the relations are the following: 3 is less than 24, or 24 is 8 times 3, or 24 is 21 more than 3. Often there is more than one pair of numbers connected with a problem, and *the relationship between the numbers is the same (constant) for all of the pairs*, e.g., proportion (4:41). The following example illustrates a form of interpretation exercise which has been used successfully with tables, graphs, and other presentations which involve several items of data and exhibit trends (9).

Example. The students in a health class were studying the number of hours of sleep needed by boys and girls. One student brought in the table at the right showing the number of hours of sleep needed at several different ages. The students noticed some definite relationships between pairs of numbers. *Directions:* Study the table and the statements below. Suppose the facts stated in the table are true. If you *agree* with a statement which follows, put *A* on the line by the statement. If you *disagree* with a statement, put *D* on the line. If you can neither agree nor disagree, but are *uncertain*, put *U* on the line by the statement.

Age (A)	No. of Hours (H)
6	14
8	13
10	12
12	11
14	10
16	9

_____ (1) As the age increases from 6 to 16, the number of hours of sleep needed decreases.

_____ (2) The number of hours of sleep needed at any age is greater than the age.

_____ (3) In this table the ratio of the number of hours of sleep to the age is constant.

_____ (4) A four-year-old should have 15 hours of sleep.

_____ (5) A twelve-year-old only needs about half as much sleep as a six-year-old.

_____ (6) From age 6 to age 16, for every 2 years that your age increases you need one hour less sleep.

_____ (7) A person 30 years old needs very few hours of sleep.

_____ (8) If the number of hours of sleep needed is subtracted from 17, the result is half the age.

_____ (9) A person 15 years old should have about 9½ hours of sleep.

_____(10) If the number of hours of sleep needed is subtracted from 17, the ratio of the result to the age is constant for all ages in the table.

Another principle useful in interpreting relationships may be stated as follows: When a number of computations follow a similar pattern,

the work can often be greatly simplified by use of relationships which exist between the results.

Example. Joe's class was studying pyramids and decided to compare the volumes of three different pyramids, as shown in the table below. All three have the same height, 15 in., and the base edges of all of them are the same length, 10 in.

Base of Pyramid	Formula for Area of Base	Height	Volume: $V = \frac{Bh}{3}$
(1) Square	$B = S^2$	15	
(2) Equilateral triangle	$B = .433\ S^2$	15	
(3) Regular pentagon	$B = 1.720\ S^2$	15	

You are to compute the volume of each pyramid.

(1) The volume of the triangular pyramid is approximately what per cent of the volume of the square pyramid?
(2) It is easy to get the answer to question 1 without pencil and paper. Explain how.
(3) The volume of the pentagonal pyramid is approximately what per cent of the volume of the square pyramid?
(4) The answer to question 3 is also easy to get without pencil and paper. Explain how.
(5) The volume of all three pyramids may be found by only five multiplications (or by four multiplications and one very easy division). Explain how this can be done.
(6) Another set of three pyramids like these has the same bases, but the height of each is only 3 inches. If the correct answers are already in the table above, what is the easiest way to find the volumes of this new set of pyramids?

For the Field of Symbolic Thinking:

i) Increasing appreciation of the economy and the power resulting from the correct use of symbolic techniques.[13]

Example. Which three of the following are the best reasons for using letter symbols like x, y, a, and b, to represent numbers in algebra?

(1) They make it possible to indicate relations or operations with unknown numbers.
(2) They make it possible to solve problems that could not be done by arithmetic alone.

[13] This objective is included under "principles" because an analysis of the meaning of the term *appreciation* as used in this context indicates that certain "understandings" or "principles" are basic to the desired "appreciation."

(3) They make it possible to discover other number relationships in a problem by using those that can be recognized easily.
(4) They are needed because negative numbers are used in algebra.
(5) One letter may be used to represent or stand for many different numbers.

It seems, however, that rather than seek always to measure the associated understandings by short-answer techniques, the teacher would be better advised to: (*a*) be on the alert for problem situations in which the understandings are useful; (*b*) analyze very carefully the way in which the understandings are related to the problem; (*c*) formulate one or more direct questions which seek to bring out the understanding. The teacher should ask for the usual *solution* of the problem, and, *in addition,* for answers to the questions he has formulated. A slight modification of this method, and a set of illustrative questions, is given below.

Example. In solving a problem in science, Bill had to multiply two numbers. He wrote them in "standard form" as follows:

$$a = 2.18 \times 10^4;\ b = 4.09 \times 10^3;$$
$$ab = 2.18 \times 10^4 \times 4.09 \times 10^3 = 8.92 \times 10^7$$

(1) If there were no knowledge of exponents, how would these numbers be written? Write them here in that way.
$a =$ __________; $b =$ __________; Product = __________.
(2) What advantages are there in *writing* numbers as was done in the solution above?
(3) Does the "standard form" method save any work in the *process* of multiplication? If so, how?

Understandings Involved in Practical Applications

The examples which follow were selected to show that the measurement of application can rise above the level of formal textbook exercises.

At the close of a unit of work, use an assignment of the following type. (1) The pupils should make a list of the principles which have been studied; (2) each pupil should select three (or some other convenient number) of the principles and find a good practical application of each; this application should be different from any given in his textbook. See that materials in the form of other textbooks and references (e.g., books on aeronautics) are available in the school library or in a classroom library. These applications are to be explained in writing. In addition, each student may give an oral presentation to the class of one of his applications. Class and teacher should

evaluate the presentation in terms of clarity, understanding of the principle shown, interest of the application selected, use of charts, drawings, pictures, to make the explanation clear, etc.

Encourage the students to bring in pictures or clippings from newspapers and magazines which illustrate the application of mathematical principles. Such materials are commonly used for bulletin board displays and motivation. They are increasingly common in textbooks. If one or more pictures or clippings illustrating the application of a mathematical principle are available, and have *not* been previously discussed by the pupils, they may be used for evaluation. Post them, or have them passed around, and direct the students in turn to examine them and then write a sentence or two which indicates the main mathematical principle illustrated. If an opaque projector is available, pictures or clippings may be thrown on a screen and viewed by the entire class simultaneously. The clippings should, of course, be filed for future use and a collection thus built up.

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CHAPTER IX

THE MEASUREMENT OF UNDERSTANDING IN THE LANGUAGE ARTS

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The language arts as a field of instruction may be considered as comprising two main areas of communication skills: (1) the *expressional skills,* involved in writing and speaking, and (2) the *receptive skills,* involved in reading and listening. Each presents somewhat different problems in the analysis and appraisal of meanings. The objectives of the language arts outlined in this chapter are grouped, therefore, under these two headings.

All language-arts objectives and outcomes are stated in terms of the student's relative growth. At an elementary stage of the development of a specific skill or ability, the teaching may include only one objective, or even be limited to a very simple phase of a single objective. At later stages, other objectives are added until at the more advanced levels there may be a complex series of interrelated objectives. Furthermore, a given objective will acquire increasingly complex meanings and higher standards of expectancy at progressive stages in the development of the skills.

The question of whether or not the specific language objectives and skills actually involve meaning and understanding depends upon how they are attained. In this discussion it is assumed that the phases of method that develop meaning in the study of the communication skills are (1) the utilization of real and lifelike situations within the possible experience of the learner which call for communication, (2) the creation in the individual of a feeling of the importance of communication in these situations, and (3) the presentation of instruction organized around both of these phases of the real situation.

The organization of this chapter follows the natural two-fold divi-

sion of the subject. First, there is a statement of the objectives of written and oral expression, followed immediately by selected examples and suggestions of appraisal methods and evaluative techniques paralleling these objectives and their related skills. These examples of evaluative procedures vary in form from subjective estimates and opinions to testing devices of high objectivity. Second, the objectives and the evaluative procedures in the fields of reading and listening are presented in a similar manner.

The Expressional Language Arts[1]

The primary purpose of instruction in language expression is to equip individuals with the power to use language effectively as a tool of communication in all of the customary situations of life which demand expression. The closer instruction can come to creating lifelike situations in which expression is required, the more meaningful such instruction will be. Consequently, in this discussion, the objectives of language teaching are grouped in terms of expressional needs in the belief that instruction and evaluation will, therefore, be built around needs rather than around isolated skills and abilities. Thus, in this outline the functional objectives (life needs) of language expression are stated first. Then each general objective is broken down to show the special skills, abilities, and knowledge by which that objective is attained. It is largely in terms of these specific skills and abilities that appraisal of the end products is possible.

The three main divisions of this section present (A) the functional objectives of oral expression and the enabling objectives or skills and abilities that are related primarily thereto, (B) the functional objectives of written expression and the enabling objectives that are identified primarily therewith, and (C) those general and underlying skills and understandings that (1) are present in all oral expression, (2) are involved in all written expression, or (3) are essential to both oral and written expression. The social importance of oral language justifies the presentation of its list of life needs before introducing the objectives of written language. The third division of section (C) is concerned with certain of the broader, more general elements of expression, often difficult of evaluation but none the less basic to effective expression. Appraisal of certain of these general objectives is naturally much more difficult than in the case of many of the more specific skills and abilities which are related to the objectives of oral and written expression.

[1] Prepared by Harry A. Greene, State University of Iowa, with helpful suggestions from Robert C. Pooley, University of Wisconsin.

Illustrative appraisal and evaluative techniques are presented in this chapter in connection with the outline of expressional objectives. In many instances the suggested procedures are quite general and often almost entirely subjective. This is particularly true in the case of the appraisal of many of the general knowledge objectives and skills that underlie all types of expression. For the most part the final appraisal of expression involves some method of evaluation of the total product, as well as of the skills and abilities which are related to the stated objectives.

Objectives and Evaluative Procedures in Language Expression

A. Functional Objectives (Life Needs) of Oral Expression.

1. To greet others easily and courteously in social situations.

   Evidence of adequate social adjustment is best shown by the ease and courtesy of the individual in meeting others in all types of social situations. Appropriate criteria of evaluation are:

   a) Does he sense the relation of existing conditions to the suitability of the greeting?

   b) When strangers meet is he sensitive to the need for and the proper form of introductions?

   c) When entering or leaving a social group can he do so without unduly interrupting the conversation?

2. To use the telephone courteously and efficiently.

   Courteous and efficient use of the telephone involves a mastery of many mechanical skills, speech skills, and good manners. The following are examples of evaluative devices.

   a) Demonstration check on placing a telephone call. Send a pupil to the telephone instrument at front of classroom. Have members of the class mark him plus or minus on the following points:

      (1) Lifts and holds instrument properly
      (2) Gives number to operator clearly
      (3) Dials a number, or explains how to dial a number on a dial telephone
      (4) Operates, or explains how to operate, a coin-box telephone
      (5) Speaks directly to mouthpiece
      (6) Asks clearly for the person he wants
      (7) Identifies himself after being connected with the person called
      (8) Concludes his call courteously

   b) Check test on good form in answering the telephone.

      (1) When answering a ringing telephone, which of these actions are to be preferred?

         (*a*) Lift the receiver and wait for the person to speak.
         (*b*) Say, "Hello."
         (*c*) Say, "Hello, this is Bill Smith."

(*d*) Say, "The Smiths' house, Bill speaking."
(*e*) Say, "Guess who this is."

(2) When asked to call someone else to the phone, which answers are preferred?
(*a*) "Just a minute please, I'll call her."
(*b*) Make no answer, but call, "Hey, Mom, you're wanted on the phone."
(*c*) "Who is this please? Yes, Mrs. Smith, I'll call her."
(*d*) "I'll get Mr. Brown for you. Hold the line, please."

3. To tell a story or personal experience effectively and interestingly.

The success of an oral story rests upon the audience appeal of the incident, the selection and arrangement of details, and the animation of the narrator. The following criteria may be used for evaluating pupils' presentations.

a) Standards for selecting a good topic for an oral story:
(1) Was the incident unusual, startling, or very amusing?
(2) Did you see it, or take part in it yourself?
(3) Can you make the characters of your story speak for themselves?
(4) Does the story end well—a surprise, or a satisfactory outcome?

b) Points for arranging the details of a story:
(1) When, where, and under what circumstances did the incident take place?
(2) Who are the characters? Does each one have a distinctive part?
(3) What fact or happening started the incident?
(4) What facts complicated the incident?
(5) What did the incident lead to?

c) Standards for judging an effective story teller:
(1) He looks directly at the audience.
(2) He speaks clearly and not too rapidly.
(3) He avoids "and-uh" and other sounds between sentences.
(4) He uses descriptive words.
(5) His face reflects his thoughts.
(6) He uses appropriate gestures.
(7) He is relaxed and at ease.

4. To report information gained by observation, interview, or reading.

A check list may be used for evaluating an oral report. For example, the teacher or class may be asked to place a plus or minus sign after each point in the following outline to indicate the success or deficiencies of the pupil's report.

a) *Title:* Descriptive ( ); specific ( ); interest-provoking ( ); accurate for content of report ( ).

b) *Plan:* Opening sentences reveal plan of report ( ); divisions of report are clearly indicated ( ); transition from one step or part to the next is shown ( ); a definite conclusion is reached ( ); the plan is appropriate to the material ( ).
c) *Facts and Sources:* Sources of information are named ( ); quotations are clearly cited to their sources ( ); facts are presented clearly, with figures, diagrams, etc. ( ); facts are reported accurately ( ).
d) *Delivery:* Speaker addresses audience ( ); material is presented convincingly ( ); speaker is relaxed and at ease ( ).

5. To give clear directions, explanations, or announcements.

This objective may be evaluated in terms of the ability to collect essential information and to present it in orderly, condensed form.

a) Have pupils prepare to give oral directions to a stranger to reach the nearest railway station, or other significant point, from their homes. Check the directions for these qualities:
   (1) Is the presentation clear?
   (2) Is all of the information given in correct order?
   (3) Is all the needed information given?
   (4) Are the directions given without hesitation, interruptions, or changes?
b) Have pupils prepare announcements suitable for a school assembly. Check the announcements for these qualities:
   (1) Does the opening statement arouse interest?
   (2) Are the facts clearly presented?
   (3) Are all essential facts given?
   (4) Is the announcement made briefly and with enthusiasm?

6. To participate in conversation, group discussion, and meetings.

Appraisal procedures involve consideration of attitudes as well as knowledge.

a) Standards for checking participant in a conversation, meeting, or panel discussion:
   (1) Willingness to listen while others speak.
   (2) Courtesy in interrupting or correcting a speaker.
   (3) Conciseness in presenting his own views.
   (4) Willingness to yield the floor, or give way in conversation, when it is appropriate to do so.
   (5) Willingness to accept and weigh opinions contrary to his own.
   (6) Sensitivity to the right of all in a group to participate freely and equally.
b) Check list of parliamentary procedures for teacher or class:
   (1) To address the chair correctly.
   (2) To nominate a person to office.
   (3) To close nominations.

(4) To second a motion which has been made.
(5) To make an original motion.
(6) To move to adjourn.
To these fundamentals may be added:
(7) To amend a motion.
(8) To refer a motion to a committee, to postpone, or to lay on the table.
(9) To rise to point of order, or to ask special privilege.

7. To take part in a dramatic production.

Pupil achievement may be evaluated on the following bases:

a) To project the character of a play to the audience, the pupil must:
   (1) Understand the character he is presenting.
   (2) Enter imaginatively into the life of the fictitious character.
   (3) Subordinate or eliminate personal idiosyncracies.
   (4) Work co-operatively with other members of the cast.
b) Ability to read lines convincingly is the product of speech skills and imagination. The successful pupil will:
   (1) Forget that the lines are printed, and read or deliver them as natural speech.
   (2) Use clear articulation to make his words audible to a large group.
   (3) Reinforce the lines with natural and appropriate movements and gestures.
   (4) Play to and with the other characters of the play as though they were the actual characters they represent.

B. Functional Objectives (Life Needs) of Written Expression.

1. To use correct form and content in all social and business correspondence.

This objective calls for the exercise of good judgment, the use of special knowledge of different forms, and a mastery of the important mechanical skills of capitalization, punctuation, and spelling.

Examples of evaluative procedure are:

a) The following informal friendly letter is not written in good form. Study it carefully. Find the parts of the letter. Then write the letter correctly on a suitable sheet of paper. Use capitals and punctuation marks correctly. Sign your own name.
   room 302, maplewood school pocono city texas june 11 1945 dear mr. ray our class voted your explanation of the way the gyro-compass works one of the most interesting talks we have had in our room this year we would like to have you visit us again some time thank you so much for your trouble yours very sincerely
b) Which of the following types of headings (A, B, or C) would be required in a friendly letter from the Fourth Grade to the Third Grade in the Lowell School?

(A)	(B)	(C)
1013 Market Street	Lowell School	1401 Cedar Street
Lansing, Georgia	Room 4	April 28, 1945
April 28, 1945	April 28, 1945	

c) Which of the above headings (A, B, or C) would be suitable for use in a business letter? ________

d) Study the following situations. Which would be suitable for use in an informal friendly note to Bob Snow?

(A)	(B)	(C)	(D)
Dear Sir:	Dear Mr. Snow:	Dear Bob,	Gentlemen:

____

e) Which of the above salutations would be suitable for use in writing a friendly letter to Mr. Robert Snow, an older business man? ________

f) Which of the above salutations would be suitable for use in writing a business letter to the firm of Snow, Brown, and Company? ________

2. To fill in certain forms and items of information as evidence of understanding.

Filling in forms requires an understanding of the facts called for and the ability to write them briefly and correctly in the proper places and in keeping with the purpose to be served. Two examples are noted.

a) Fill the following blanks correctly. Use information about yourself.
Name________________________ Age________ Grade________
Street Address ____________________________________
City or Town________________________ State____________
Name of Parent____________________ Telephone Number______

b) Manuscript form is largely a matter of local school practice and approval. Evaluate it mainly in terms of the consistency with which the policy of the local school is followed by the individual.

3. To write creatively a story, essay, or verse for personal pleasure, or for the entertainment or information of others.

The success of creative writing rests upon (*a*) the selection of a suitable topic or title, (*b*) the selection and organization of suitable and pleasing details, and (*c*) a spontaneous interest in the production and a desire to *create* for enjoyment. Results may be judged on the following bases:

a) Standards for choosing a topic for a creative effort in writing. Check for affirmative responses:
   (1) Is the incident, the thought, or the plot unusual, startling, or amusing?
   (2) Is it real to you as an author?
   (3) Will its telling give you and others pleasure?

b) Points for arranging the details of the story for effectiveness of presentation. Check for affirmative responses.

(1) Who are the characters? Is each distinct?
(2) When, where, and under what circumstances did the incident take place?
(3) What started or complicated the incident?
(4) What did it all lead to?

4. To write a telegram, notice, announcement, or advertisement.

This type of writing is dependent upon the ability to select only the essential facts, and to choose words that express the meaning briefly and concisely. Simple exercises may be used to determine the pupil's understanding of these requirements.

a) You have missed a train connection in Chicago and will be delayed twelve hours in arriving home. List the facts you would include in a telegram to your parents explaining the delay.

(1)________	(3)________	(5)________
(2)________	(4)________	(6)________

b) Write a telegram of ten words or less telling the facts in (a) above.

c) As chairman of the committee on arrangements you are to write a brief announcement stating the essential facts regarding a class meeting.

5. To outline content and factual material from sources.

The ability to select and organize essential facts in their proper relationships is closely related to understanding. Evidence of understanding is best shown by skill in the use of correct outline form as required in the following exercises.

a) In making an outline, which should be used to indicate main heads? (1) Roman numerals (2) Capital letters (3) Small letters ________

b) Which of the above (1, 2, or 3) should be used to indicate two or more subheads under a main head in an outline? ________

c) Read the following paragraph. At the right is an outline form partly filled in. Complete the outline.

Preparing Rice for Market

From the fields the grain is taken to the rice mills where it is threshed, cleaned, and husked. Next each little grain is polished by a special process. Finally the rice is graded, weighed, and packed for the market.

Many of the mills are small and limited in capacity, turning out less than 1,000 bushels of rice per day. Some of the larger ones prepare as many as 10,000 bushels of rice for the market every twenty-four hours.

Preparing Rice for Market

I. Functions of Rice Mills
   A. ________
   B. ________
   C. ________
   D. ________
   E. ________
   F. ________
   G. ________

II. Capacity of Rice Mills
   A. ________
   B. ________

6. To prepare a bibliography or selected list of reference sources.

The preparation of a bibliography or list of reference sources requires the ability to select and evaluate the materials and to present them in correct bibliographical form. The following are examples of appropriate testing procedures.

a) You are looking for information to answer the following questions. Under which of the items following each question would you be most likely to find the answer?

(1) How does U. S. rank among the countries of the world in oil production?
(1) Russia (2) Petroleum in U. S. (3) South American Oil (4) British Control of Oil in Iran ______

(2) How much does the Suez Canal reduce the distance by water from London to Calcutta, India?
(1) Water routes to the Orient (2) Suez to India (3) Panama Canal (4) South Africa ______

b) The book *"Lasius: The Lucky Ant"* was written by Nina A. Frey. It was published by E. P. Dutton and Company in 1938. Rewrite this information correctly in bibliographical form.

7. To keep records and minutes of group meetings.

Success in recording minutes of meetings depends upon an understanding of the essential facts and procedures in parliamentary practice. A check list is a convenient device for testing understandings of this type.

Check each item below that must be included in the record (minutes) of a club meeting in order that the full purpose of the meeting may be recorded exactly.

______ (*a*) The name of the club
______ (*b*) The name of the founder of the club
______ (*c*) Where or when the meeting took place
______ (*d*) Who presided at the meeting
______ (*e*) The name of the president and vice-president
______ (*f*) Reading and approval of minutes of last meeting
______ (*g*) The list of all members present
______ (*h*) Each motion with resulting action; the names of its maker and those who seconded it
______ (*i*) The nature of the program if one was given
______ (*j*) The time of adjournment
______ (*k*) The secretary's signature
______ (*l*) The president's signature

8. To sense the need for certain types of written communication and the suitability of materials to be used.

Evidence of an understanding of materials used in writing is shown by the individual's response to writing needs and by his use of suitable

materials for the purpose. The following test exercise illustrates one method of evaluating understanding in this area.

Show for each of the following the proper material to be used in writing. Write the correct number on the line before each exercise.

______	(a) A note to the grocer boy to put the meat in the icebox on the porch	(1) Written on plain paper
______	(b) An application for a position in an office	(2) Written in longhand with a pencil
______	(c) A note of thanks to your hostess for dinner	(3) Written in longhand with blue or black ink on plain note paper
______	(d) A formal note of regret	(4) Written in longhand with blue or black ink on tinted note paper
______	(e) A cordial letter to a friend	(5) Written in longhand with brown or green ink on tinted paper

C. General and Underlying Skills and Understandings

1. Skills and abilities common to all oral expression

a) To use a clear, properly modulated voice in all oral expression.

The use of a pleasantly pitched, properly modulated voice affects the interpretation of the meaning of the thoughts expressed by the speaker. Check for affirmative answers to these questions as evidence of understanding:

(1) Does he appear to "hear" his own voice in each speaking situation?

(2) Does he unconsciously adjust his voice placement as required by the speaking situation?

b) To enunciate clearly and pronounce words correctly.

Clear enunciation of all verbal sounds and the omission of all non-verbal sounds are evidence of understanding as well as of skill in oral expression.

2. Skills and abilities common to all written expression

a) To master and use correct general manuscript forms required in all writing.

Understanding of techniques of presenting ideas in written form is indicated by neat legible writing, correct spelling of essential words, recognition of demands for good manuscript form, and the use of capitalization and punctuation as required by the meaning situation. The best evidence of such understanding is the use of a quality in one's daily work which is adequate to make his meaning clear. Such exercises as the following may be used in this connection.

(1) In the following sentences some words are written with small letters that should be capitalized and some are written with capitals that should begin with small letters. Go through the following story carefully correcting all mistakes in using capitals.

(*a*) did jack ride to town with father?

(*b*) no, but i think your Mother went with him.

(*c*) she probably took the Baby in to see dr. scott.

(2) In each of the following sentences one or more punctuation marks have been omitted. Place the correct punctuation marks where they belong.

(*a*) Werent you expecting me

(*b*) Be careful That dog is cross

(*c*) Dont you hear me Mother called Joan

(3) The following story is not written in good paragraph form. Write the story correctly on a sheet of paper, using appropriate margins and correct paragraph form.

The fact that my kitten is black is not the reason why I call him Bad Luck. He is always in trouble. Saturday he broke one of Mother's best flower pots. Yesterday he scratched the baby's hand. Today he chased Potsy, my puppy, right through our front door screen. Everyday he is Bad Luck.

3. Skills and abilities common to all language expression

a) To use courteous and correct attitudes and expression in all types of social situations.

Courteous attitudes involve awareness of the rights of self in relation to others. Suitability of expression is a matter of understanding what the situation calls for as well as of knowing what is correct. Check for affirmative answers to such questions as:

(1) Does the individual utilize only his fair share of time as a speaker in conversational groups?

(2) Is he willing to be listener part of the time?

(3) Does he sometimes intentionally throw the conversational activity to another in the group?

(4) Does he stimulate a group or a speaker by appearing to be an interested listener?

(5) Does he understand that there are times and places when it is better to keep silent?

(6) Is he familiar with the forms of expression which are appropriate to the audience situation?

(7) Is he sensitive to the need for the use of certain forms of expression for the prevailing purposes?

b) To select suitable and pertinent material.

The selection of suitable material and pertinent facts is a matter of understanding and judgment developed through training and

experience. Check for affirmative responses to the following questions.

(1) Does the individual choose simple and even commonplace events?
(2) Does he select fields in which he is informed?
(3) Does he recognize the audience appeal of experiences common to all?
(4) In the selection of facts and illustrations is he sensitive to the maturity and interest levels of his audience?
(5) Does he completely grasp the point of a story or joke before proceeding to relate it to others?
(6) Does he investigate the correctness of the facts used in statements?
(7) Does he know where to look for interesting, essential, and correct facts?
(8) Is he a master of the tool skills required in the location and verification of facts?
(9) Is he sensitive to the differences in the materials required by fact and fiction?
(10) Does he sense the elements of propaganda?

c) To organize and express thoughts logically, clearly, and effectively in sentences or in larger units.

The logical organization of thoughts into clear and effective sentences and paragraphs includes a clearly defined sentence sense based upon an understanding of word meanings and of the use of words as expressive and connective devices. Use tests such as the following.

(1) Are these groups of words sentences? Draw a line under Yes or No.

(*a*) On the way to school.	Yes	No
(*b*) He has lost his pencil.	Yes	No
(*c*) Please be quiet.	Yes	No
(*d*) Baseball in the park.	Yes	No

(2) In each exercise below part of a sentence has been cut off by a period. Write each sentence correctly.

The pup grabbed the bone. And ran out into the yard.
With a cross growl. Dixie started after him.

(3) Put a cross through every *and* that is not needed in the story below. Put in capital letters and periods where they are needed to make good sentences.

I have a big white rabbit and his name is Bumpo and every morning he sits up and begs for a handful of clover and one day I went to feed him and he was gone and I found that he had dug out of his pen.

(4) Place an x before the one sentence in each group of three that represents the best sentence structure.

(*a*) ______ I counted six paintings walking down the stairs.
______ While walking down the stairs six paintings were counted.
______ While I was walking down the stairs I counted six paintings.

(*b*) ______ He dropped the bundle he was carrying to his mother in the mud.
______ The bundle fell into the mud which he was carrying to his mother.
______ Into the mud fell the bundle which he was carrying to his mother.

d) To clarify meaning through variety.

Variety in sentence structure and form is the result of skill in the arrangement of words and phrases in effective order, the use of compound subjects, compound predicates, and compound and complex sentences. Such skill with sentences is the best evidence of the understanding of the speaker or writer, and may be measured by such devices as:

(1) Rewrite these sentence to make each more interesting by changing the position of certain words or phrases.
  (*a*) The doorbell rang last night just as I was going up to bed.
  (*b*) A boy stood there with a telegram in his hand.

(2) Combine these pairs of sentences into single sentences using compound subjects.
  (*a*) The tomatoes in my garden were damaged by the hail. The cabbage was damaged also.
  (*b*) The Seventh Grade class is having a sleighride party Friday night. The Sixth Grade class is having a sleighride party also.

(3) Combine these pairs of sentences into compound sentences.
  (*a*) The clouds were tossed by the wind.
  The storm did not strike us at all.
  (*b*) The band was playing in the park.
  Music seemed to fill the air.

(4) Rewrite the following sentences, changing one of the independent clauses in each to a dependent clause.
  (*a*) Mr. Steele is our school principal, and he is also our football coach.
  (*b*) The storm began at eight o'clock, and it lasted until the show was over.

e) To clarify meaning by choosing suitable, concise, simple, colorful words.

The use of effective, concise, and colorful words results from sensitivity to the utility and artistic values of words, and skill in the use

of the dictionary and other sources in the extension of word meanings and vocabulary. Rewriting exercises may be used in evaluating these abilities.

(1) Read this sentence: The frightened fox *ran* into the woods. *Ran* is not a particularly exact or vivid word. Write as many sentences as you can using exact, vivid, and interesting verbs in place of *ran*. Use your dictionary to locate synonyms if you need to.
Example: The frightened fox *sneaked* into the woods.

(2) Read this sentence: A stream wound through the meadow.
With the help of your dictionary to locate synonyms choose colorful and vivid pairs of adjectives to add to this sentence to make a clear picture. Write the sentence several times using different adjectives to change the picture.
Example: A *deep dark* stream wound through the meadow.

(3) Rewrite the sentences in (1) and (2) above adding vivid adverbs telling *how* in the sentences.

f) To clarify meaning by following correct language usage.

Correct usage of pronoun and verb forms, subject-predicate relationships, the avoidance of miscellaneous errors, such as double negatives, vague antecedents and redundancy, is a matter of correct habit closely related to understanding in expression. The following are examples of appropriate test items:

(1) Rewrite the following sentences, selecting the correct pronoun from those in the parentheses.
(*a*) (He, Him) and (I, me) were born in the same town.
(*b*) Mother sent (we, us) girls to the store.

(2) Rewrite the following sentences using the correct verb forms from those in the parentheses.
(*a*) (Was, Were) you at the show last night?
(*b*) It (doesn't, don't) seem so cold now.

(3) Faulty expressions appear in these sentences. Rewrite the sentences correcting all mistakes.
(*a*) Where did you see him at?
(*b*) We haven't hardly no time left.

g) To clarify meaning by audience appeals.

Skill in sensing audience reactions and in the use of devices such as anecdotes, humor, illustrations, sentence variety, and similes to create interest is related to the total meaning of the expression situation. Positive answers to the following check questions are evidence of understanding.

(1) Does the speaker or writer react sensitively to audience interests and moods?

(2) Does he quickly adjust the tone of his presentation to that of his audience?
(3) Does he sense the need for the use of anecdotes and humor?
(4) Does he properly evaluate the suitability of anecdotes and stories to the audience situation?
(5) Does he appear to understand the situation clearly enough to make proper use of sentence variety, similes, and illustrations?

The Receptive Language Arts [2]

One of the chief purposes of instruction in the arts of reading and listening is to enable individuals to understand and react intelligently to all they hear and read in customary life situations. Thus conceived, reading and listening comprise the basic aspects of the receptive language arts. The closer instruction can come to creating purposeful life situations in which reading and listening are required, the more meaningful and effective such instruction will be. Accordingly, the objectives of reading and listening with special reference to meaning are listed here in terms of life situations which call these arts into use. These life situations, of which only a few typical examples can be mentioned, are classified as (A) those which relate to practical needs and (B) those which relate to recreational purposes.

Following the list of functional objectives an effort has been made to identify the knowledge, attitudes, skills, and procedures that are involved in effective reading and listening. In this connection it has seemed advisable to identify in Section A those that are common to both reading and listening, thereby emphasizing the similarity of the two processes and the common problems involved in promoting efficiency in the two phases of the receptive language arts. The analysis is extended in Section B to include supplementary attitudes, skills, and procedures of major importance in many silent reading activities, and in Section C, to those essential in effective oral interpretation.

The number of functional objectives of reading and listening, and of related skills and abilities, is very large. Unfortunately, space will not permit reference to all of the important objectives or illustrations of all the useful evaluative techniques. It seemed advisable, therefore, to limit examples of evaluation techniques to selected sections of the outline. Because of its wide application, the section of the outline entitled "Essential Knowledge, Attitudes, Skills, and Procedures," was chosen. It was necessary also to limit examples to the field of reading only, rather than to include both reading and listen-

[2] Prepared by William S. Gray, University of Chicago.

ing. The examples were further limited to one type of evaluation technique in each situation, whereas many are often possible.

As in the case of the section on oral and written expression, the proposed evaluative procedures are often quite general, and more or less subjective. This is particularly true of those relating to "Motive, Problem, or Purpose in Reading," "Attention Directed to What Is Read," and "The Integration of the Ideas Gained through Reading with Previous Experience." For the most part, the appraisal techniques suggested are designed to evaluate pupil accomplishment, or progress, in terms of some form of behavior response.

Objectives and Illustrative Procedures in Reading and Listening

A. Typical situations which lead children and adults to read or listen in meeting practical life needs.

1. To find out what is going on, by
   a) Identifying appropriate sources—newspapers, magazines, people.
   b) Understanding clearly what is read or heard.
2. To find one's way about, by
   a) identifying appropriate sources—signs, folders, maps, guides, information centers.
   b) Interpreting accurately the various types of information provided.
   c) Translating the information secured into appropriate action.
3. To understand assignments and directions, by
   a) Securing a clear grasp of the meaning of what is read or heard.
   b) Seeing its implication with respect to one's procedures or actions.
4. To verify spellings, pronunciations, meanings, uses of words, by
   a) Finding and interpreting accurately the information needed.
   b) Checking previous spellings, pronunciations, meanings, and uses of words in the light of information secured.
5. To secure answers to specific questions, by
   a) Identifying appropriate sources of help.
   b) Understanding what is read or heard.
   c) Selecting the items that answer factual questions.
   d) Selecting and interpreting the items that help answer a judgment question.
6. To gather information for fuller understanding or for talking or writing on one's hobby, for preparing assigned papers and discussions, or for informing or convincing others, by
   a) Identifying appropriate sources.
   b) Interpreting what is read or heard.
   c) Selecting what is appropriate for the purpose at hand.
   d) Organizing the information secured into the form desired.

7. To learn how to act in new situations, by
   a) Locating and interpreting pertinent items of information.
   b) Formulating a plan of action.
8. To work out complicated problems, by
   a) Identifying the kind of information needed.
   b) Locating needed sources.
   c) Understanding what is read or heard.
   d) Seeing the implications or bearing of the ideas secured on the problem at hand.
9. To reach conclusions as to guiding principles, relative values, or cause-and-effect relationships, by
   a) Securing a clear grasp of the meaning of what is read or heard.
   b) Ascertaining its accuracy, relevance, significance, value.
   c) Organizing relevant items into patterns of thought which will reveal the principles or relationships involved.
10. To identify and resolve propaganda, by
   a) Securing a clear grasp of the sense of what is read.
   b) Identifying the author's intent or purpose through a deliberate study of the language used, including words with "loaded" meanings.
   c) Determining the extent to which the views expressed merit consideration.
11. To search for and discover the truth, by
   a) Identifying appropriate sources of information.
   b) Securing a clear grasp of the meaning of what is read or heard and its relation to the problem at hand.
   c) Weighing carefully all the evidence available.
   d) Isolating truth from fiction.

B. Typical situations which lead children and adults to read or listen in recreational mood.

1. To relive everyday experiences, by
   a) Understanding what is read or heard.
   b) Interpreting the ideas acquired in the light of personal experiences.
2. To have fun or sheer enjoyment, by
   a) Securing the meaning of what is read or heard.
   b) Recognizing the humor in it.
3. To escape from real life, by
   a) Reading or listening to materials that afford escape.
   b) Becoming completely absorbed in the theme or events presented.
4. To satisfy natural and valuable curiosities about strange times and places, human nature and motives, by
   a) Locating appropriate materials.
   b) Understanding, often quite fully and in detail.

5. To enjoy sensory imagery, by
   a) Grasping the meaning of what is read or heard.
   b) Visualizing or in other ways reproducing in imagination some of the ideas acquired.
6. To enjoy ready-made emotional reactions through hearing or reading romantic tales, sentimental verses, mystery stories, by
   a) Following the theme presented.
   b) Putting one's self in the place of the characters.
7. To enjoy the sentiments and ideals expressed, by
   a) Understanding what is read or heard.
   b) Reacting appreciatively to the ideas apprehended.
8. To enjoy the rhythm and quality of expression in both prose and poetry, by
   a) Reading aloud or listening to someone render them.
   b) Being sensitive to and appreciative of rhythm and suitability of expression.

Essential Knowledge, Attitudes, Skills, and Procedures

A. Basic attitudes, skills, and procedures involved in securing meaning in both reading and listening.

1. To respond to the motive, problem, or purpose.
   Appropriate evaluative procedures are:
   a) A pupil reading voluntarily during a "free reading" or "browsing" period answers these check questions:
      (1) Why are you reading at this time rather than doing something else?
      (2) For what specific purpose are you reading this book, story, or article?
   b) A pupil reading suggested references during a study period answers these check questions:
      (1) What do you hope to accomplish by reading these materials?
      (2) Do you now have any reasons for reading these references that you did not have when you first began this assignment?
   c) A pupil doing intensive reading of textbook material answers these check questions:
      (1) For what purpose or purposes are you now reading?
      (2) What specific questions do you expect to answer through your reading?

2. To direct attention to the meaning of what is read.
   Answer these questions as a check on concentration:
   a) Does the pupil appear to read with absorbed attention?
   b) Does he maintain an attitude of close attention to his reading over a considerable period of time?
   c) Does he resist distractions while engaged in reading?

3. To develop fluent, accurate perception of word forms.
   This ability may be evaluated in terms of such evidence as:
   a) Accurate discrimination of word forms.
   (Example of test item): Look at the word or phrase in the left-hand column, and underline the corresponding word or phrase at the right.
   where .... there, then, where, when.
   elegant .... elephant, element, elegant.
   at the house .... at that house, at the house, on the house.
   b) Accurate perception of both form and meaning:
   (Test): Underline the statement that makes the best sense:
   The house was built on a hill.
   The mouse was built on a hill.
   The house was built on a mill.
   c) Association of right meanings with word forms.
   (Test): After each word in List A write a word from List B which has the same, or nearly the same, meaning:

List A	*List B*
calm.............	room
	mighty
broad............	quiet
	steady
firm..............	wide

   d) Accurate perception of words in context.
   (Test): Read the following paragraph aloud just as you would if reading to a class:

   The sun pierced into my many large windows. It was the opening of October, and the clear sky was of a dazzling blue. I looked out of my window and down the street. The white houses of the long, straight street were almost painful to the eyes. The clear atmosphere allowed full play to the sun's brightness.

   Directions for evaluation: If a word is wholly mispronounced (e.g., "atmosphere"), underline it. If a word is partly mispronounced, (as "pierced," "allowed," "straight," "dazzling") mark it. Mark insertions, as in the case of "clear down the street"; omissions, as in the case of "of," and "al" in almost; substitutions, as in the case of "many" for "my"; and repetitions, as in the case of "to the sun's." An analysis of the types of errors made will reveal much concerning the nature and extent of the reader's perceptual problems.
   e) Fluent perception of words.
   By keeping a record of the time required to read the above paragraph orally, information can be obtained concerning the fluency of the reader's recognition of words in oral reading. By giving a timed test in silent reading, a measure of the pupil's fluency in

perceiving the meanings of words and phrases in context can be secured.

4. To secure an adequate understanding of what is read.
   Evidence of understanding may be noted in pupils' reactions to materials read.
   a) A clear grasp of meaning, involving:
      (1) Selection of meanings of words appropriate to the context. For example, "C-3-*d*," p. 187.
      (2) Fusion of the meanings of words into a chain of related ideas.
      (Test): Read the sentences below, and then fill in the blanks with words that make the meaning clear.
      The snow fell all day and all night. Susan had to play in the house. She felt sorry for all the birds and squirrels. They had to stay outside in the cold wind and snow.
      Susan stayed inside because the .... was cold and the .... was deep. She was sorry for the .... and ....
      (3) Recognition of the importance and relationship of the ideas acquired.
      (Test): Many inventions have helped to make flying safer and more practical. Dispatchers at all the stations on the routes flown keep in touch by radio with pilots during their journey. They give information about weather conditions, and check the positions of the planes. Frequent weather reports come into the central office by teletypewriter, so that a flyer is told the weather at any given moment at any place he approaches. Planes are guided into the landing field by radio beams, which give the pilot a constant stream of dot-dash signals to warn him when he is off his course. De-icers for the wings, and automatic signals to warn of failure to lower landing gear also add an extra margin of safety to flight.
      (*a*) Tell in a sentence the main idea of this paragraph.
      (*b*) List three statements that support the main idea.
   b) Coping successfully with such factors as:
      (1) Unusual word order.
      (Test): Show what the first line of the following sentence means by writing it as you would usually say it.
      I'd be out of the wind's and the rain's way, if I had a little, tiny house of my own.
      (2) Complexity of sentence structure.
      (Test): Read the following sentence, and follow the directions given below:
      Even after the first sextant was invented, a British explorer, Captain James Cook, saw the pride of Europe's inventive genius outdone.

(*a*) Show what this sentence means by rewriting it, beginning with "Captain James Cook."

(*b*) What question does the italicized part of the above sentence answer: how______, when______, where______, why______?

(3) Abstract ideas.

(Test): In providing for their children, parents try to deal justly with all of them.

What is the meaning of the word "justly" in the sentence above?

________ In a courteous manner.

________ In an impartial way.

________ In a kindly way.

c) Interpreting meaning in the light of its broader context.

This ability implies an understanding of

(1) The total setting of the ideas expressed.

(Test): Read the following sentence and then write as fully as you can all that is meant or suggested by it, giving special attention to the italicized words and phrases.

"When *Columbus* discovered that *Queen Isabella had granted his request,* he was overjoyed because *of the possibilities that now lay before him.*"

(2) The author's mood, tone, intention.

(Test): Read the sentences below carefully, and then answer the questions that follow:

"We are certainly a brilliant family," said Father. "We asked everyone to remember to put in the matches. Here we are ready to build a fire, and no one has a match!"

(*a*) What did father really mean by "We are a brilliant family"?

(*b*) Was it his intention to:

________ praise the family?

________ scold the family?

________ make fun of the family?

d) Supplementing the specific meanings apprehended.

Evidence of the following skills should be sought.

(1) Reading between the lines.

(Test): Read the story below, and answer the questions which follow by writing "yes," or "no." Then write the sentences, words, or groups of words in the story that prove your answer.

Matthew saw a group of red-coated soldiers marching down the road with their muskets gleaming in the sunlight. His hand groped for the powder-horn at his side, and as he did so he touched the wallet containing the letter. He felt suddenly cold with fear.

Did Matthew think the soldiers were enemies?

Is it likely that the wallet contained some secret or special message?

Is it likely that this was an incident of the American Revolution?

(2) Seeing implications.

(Test): Read the following paragraph and answer the question which follows:

Soviet Russia is primarily a land power, and will keep on needing a fairly large standing army to protect her boundary lines with neighboring states. Her navy is quite small. There is no need for a large navy, since Russia has no distant possessions to be reached by sea. We might conclude, therefore, that a large Russian army is no threat to world peace. A rapidly expanding Russian navy might present a real question.

What is the implication of "a rapidly expanding Russian navy," as stated in the last sentence, that would create a real question?

________ Russia aspires for distant possessions.
________ Russia wishes to maintain world peace.
________ Russia is afraid of other nations.

5. To react critically to what is read.

Such reactions may be evaluated in terms of the following criteria:

a) Recognizing the value, usefulness, timeliness, significance of what is read.

(Test): If you wanted to read about aircraft carriers, would you rather have a book with 1930 on the copyright page or with 1945 on the copyright page? Why?

b) Judging the validity or truthfulness of the ideas presented in a passage.

(Test): "You will need to keep your armour bright and your lance keen. The King will expect you to defeat all knights in combat, and to guard the entrance to the castle with your life. You will need to swim like a fish, and run like a deer. To help you, you will have the cloak of Prince Stephen to make you invisible, and the sword Excalibur, which will cut through wood, or stone, or steel."

Is this an historical record of a ruler's words? Justify your answer.

c) Judging the accuracy or completeness of the author's conclusions.

(Test): All citizens in ancient Athens were expected to vote, and all citizens took a deep interest in their government and their courts. No foreigners were allowed to vote, however, nor could women or slaves. The slaves did all the work of plowing, harvesting, and caring for cattle and vineyards. They also made many things of use on the farm and in the home. The women of Athens were busy at home, spinning, weaving, rearing the children, and

overseeing the work of the household. Men who were free citizens were thus able to give a great deal of their time and attention to the business of governing the city of Athens. Each man was careful to do his share, and took much pride in his great city.

Mark the following statements: (0) if it might be true, but cannot be proved by the facts stated in the paragraph; (—) if it is false according to statements made in the paragraph; and (+) if it is true and can be proved by statements found in the paragraph.

________ Athenian citizens were interested in good government.

________ Women in Athens led a very dull life.

________ Men who were citizens in Athens did much of the work.

d) Recognizing whether or not the reasoning of the author is sound.

(Test): Read the paragraph below, and answer the question which follows by writing "Yes" or "No." Then write a short paragraph of your own to justify your answer.

Intelligence tests show that the children of doctors, lawyers, and dentists are brighter than the children of factory workers and laborers. This proves that children of working-class families comprise the most stupid part of our population.

Wherein is the author's reasoning sound or unsound?

e) Identifying and resolving propaganda.

(Test): Read the advertisement below, and answer the questions which follow.

Magic Cream Oil is often used by nurses in big hospitals. A famous doctor recommends it for dry, chapped hands. Buy a jar today!

Is this advertisment one form of propaganda?

If so, the use of what words make it such?

What information would you need before you could accept as true the statements made in the advertisement?

6. To integrate the ideas acquired with previous experience so that the following evidences of understanding may be noted immediately, or later:

a) New insights are acquired.

Do the pupil's reports and discussions of materials read show an enlarged understanding or clearer insights?

b) Previous understandings are reaffirmed or modified.

Does the pupil appear to be more convinced than before of the soundness of his position, or has he modified it?

c) Challenging problems are solved.

Does the pupil show evidence through oral reports, conversation, or written assignments that he has made progress toward a clear-cut solution of one or more problems—or, indeed, that he has reached a solution?

d) Rational attitudes are acquired.

Does the pupil show increased ability to give reasonable explanations in support of his expressed views or attitudes?

e) Behavior is modified.

Does the pupil adopt a new or modified course of action as a result of his reading? For example:

(1) Does he make better choices leading to a vocation?

(2) Does he now pursue recreational activities and hobbies, whereas he formerly did not?

f) Interests are broadened.

Does the pupil evidence in his conversation, and by the books which he reads, an increasing range of interests and curiosities?

g) Richer and more stable personalities are developed.

Do comments by parents, other teachers, or playmates, as well as your own observations, indicate that the pupil may have achieved growth in desirable personality traits and in stability of character? For example is there evidence of

(1) Happier and more cordial relations with others?

(2) An apparent feeling of greater self-confidence and security?

B. Supplementary attitudes, skills, and procedures essential in many silent-reading activities.

1. To locate needed information.

Evaluation may be based on pupil's procedures in:

a) Using an index.

b) Using a table of contents.

c) Using the dictionary.

d) Using card files.

e) Using reference books.

2. To gather and evaluate information in the light of a given purpose.

Appropriate evaluative criteria are:

a) Recognizing the purpose to be achieved, such as

(1) To find answers to specific questions.

(2) To find the central thought of the selection.

(3) To follow a sequence of related events.

(4) To enjoy the facts or story presented.

(5) To identify important points and supporting details.

(6) To select facts relating to a problem.

(7) To solve a problem.

(8) To understand and follow directions.

(9) To compare the views of two or more authors.

(10) To find support for a point of view or course of action.

b) Applying appropriate fact-finding techniques, as, for example,

(1) Studying the title for a cue to its meaning.

(2) Reading carefully to find out what the author plans to do or say.

(3) Giving special attention to topic sentences or paragraphs.
(4) Reading on through the selection to note how the author arrives at his point.
(5) Grasping the author's organization of ideas.
(Note: The techniques used vary with the purpose.)

c) Sorting essential from nonessential information.
d) Judging the validity and significance of relevant information.
e) Organizing the information in terms of the purpose or problem.
f) Drawing tentative conclusions.
g) Deciding when the purpose has been achieved.

3. To adjust reading attitudes and procedures to different purposes. These adjustments are indicated by such reactions as:
a) Modifying interpretative processes in light of the purpose to be achieved. As, for example,
(1) Reading to answer factual questions.
(*a*) Selecting relevant facts.
(*b*) Remembering them until needed.
(2) Reading an organized body of material to report.
(a) Grasping the author's point of view and organization of ideas.
(*b*) Selecting points for presentation to class.
(*c*) Associating ideas together into a coherent report.
(*d*) Remembering them.
(3) Reading to determine the accuracy of the facts or events described. Illustrations are
(*a*) Selecting relevant facts.
(*b*) Comparing them with other known facts.
(*c*) Making judgments concerning their validity.
b) Adjusting rate of reading to the purpose. This involves
(1) Reading slowly and carefully when a thorough understanding of relatively difficult material is desired.
(2) Reading rapidly merely to find out what is in an article or to enjoy a story.
(3) Skimming to determine if an article contains relevant material or to locate specific items of information.

C. Supplementary attitudes, skills, and procedures essential in interpretative oral reading.

1. All those listed in "A" above (pp. 190 ff.) to insure a thorough grasp of the author's meaning. (See also "A-7" of the section on Expressional Language Arts, p. 180.)
2. All those common to oral expression as listed in the section of the chapter entitled "General Expressional Knowledge, Skills, and Abilities," for example:

a) Using a clear, pleasant, properly modulated voice.
b) Enunciating words clearly and pronouncing words correctly.

3. Having a compelling motive for reading to others.
4. Sensing the importance of the message for the audience to whom it is read.
5. Adjusting manner and speaking voice to size of room, character of selection, and needs of the audience.
6. Modulating the voice to bring out thought relationships clearly.
7. Adjusting the voice to changes in character and mood.
8. Adjusting rate of reading and the grouping of words to the rhythm of poetry.
9. Using appropriate facial expression and gesture, subordinated to the thought of the selection.
10. Controlling bodily movements and breathing.
11. Feeling confident of one's ability, free from tension, convincing in manner and speech, and natural and sincere.

CHAPTER X

THE MEASUREMENT OF UNDERSTANDING IN THE FINE ARTS

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A discussion of measurement with emphasis on understanding as presented in Section I of this yearbook has great significance for teachers of the arts. Of particular value to them are the varied procedures indicated for obtaining evidence of understanding: observation of individuals during regular day-by-day class work, oral questions, class discussions, reports, and other non-group testing procedures. Too often when measurement is considered teachers think only of administering to their entire group of students a paper-and-pencil test in which there is one best answer to each item. Teachers of the arts have not been enthusiastic about such tests, which in their field of work have been far from satisfactory. The truth is that in the arts any extreme emphasis on uniformity, objectivity, and ease of administration in the making of tests easily leads to a concentration on the most mechanical and superficial aspects of the learning process, and the result can be the development of a measuring instrument not only useless, but positively dangerous and misleading. Accordingly, emphasis is here placed upon criteria and procedures for measurement which a teacher may fruitfully use to judge the endeavors and productions of learners in the arts, because they discriminate and reveal the essentially meaningful aspects of artistic learning.

OBJECTIVES IN ART EDUCATION

In general, it seems clear that all significant progress and learning in any of the arts must be regarded primarily as progress and learning in aesthetic insight and power. This can properly be described as an advance in understanding since it means an increasing power to dis-

criminate and respond to essential aesthetic values, and to realize those values in action. Thus, the use of the word "understanding" is entirely legitimate, so long as its true meaning is kept steadily in mind.

Technical or intellectual progress—that is to say, advance in sheer skill and dexterity, or in knowledge about the arts, or in capacity to analyze an art work structurally or historically—must, however, be regarded as secondary. In and of itself, no such advance can be taken to constitute progress in artistic understanding, because the very essence of the arts is omitted. Technical or intellectual learning, therefore, should never be given a primary place by any teacher who wishes justly to evaluate a pupil's progress in any of the arts. The first consideration must always be advance in aesthetic insight and power. A brief explanation of what this means is in order before passing on to criteria and procedures for measurement.

The essence of the aesthetic process in all its manifestations and at all levels is the objectification or projection of emotional experience in and through organized design. The medium in which the design is fashioned may be visual, as in painting, sculpture, or architecture. It may be auditory, as in music. It may be verbal, as in poetry and prose. It may involve many sense media, as in drama, opera, or the motion picture. Sometimes the precise nature of the sensory medium out of which the design is built may be open to debate, as with the dance, which presumably combines the kinaesthetic and the visual. But in any case, the point and function of the design is that it embodies and renders public a way of feeling. In this lies the distinction between what can and cannot properly be termed "art." A system of geometry or an administrative arrangement is a design or pattern just as genuinely as the plot of a play or the organization of a picture. But in the two former cases its function is entirely different. It does not embody and make public a way of feeling. Indeed the emotion of the originator, however deep and strong, does not penetrate the result at all, and is irrelevant to it. All authentic aesthetic activity, then, from the level of the child to that of the most highly developed artist, essentially involves the use of the design for the projection of affective values.

The aesthetic process appears in three closely related yet distinguishable modalities. First, there is *artistic production*, in which a way of feeling is exhibited in the fashioning of a wholly new expressive design, instances being the composition of music, the painting of pictures, the writing of poetry, and the like. This is often called "creation" *par excellence,* although the word has come to carry considerably broader meanings. Second, there is *artistic reproduction* or perform-

ance, in which an expressive design already fashioned is projected anew by an individual or a group intent on realizing the emotional intimations which it embodies, instances being the performance of music, the presentation of a play, or the reading aloud of poetry or prose. Performance, or reproduction, of course, has a very minor part in the purely visual arts. Third, there is *artistic enjoyment* (often spoken of as "appreciation") in which persons respond to the intimations embodied in visual, auditory, or verbal design. All three of these modalities are involved in any adequate scheme of art education. It is of supreme importance that they be treated always as manifestations of the aesthetic process, which means that they are authentic only as responses to design functionally significant as a carrier of emotional values and meanings.

The furtherance and development of this characteristic process is the central purpose of artistic education of all types and at all levels. Otherwise it simply ceases to be artistic education, and becomes training in skills such as those of descriptive drawing, music reading, controlled bodily movement, and the like, or the promotion of knowledge and intellectual insight. It is not denied that skills related to the arts, or knowledge about and intellectual insight into them, may have important values. But in and of themselves, they are outside the sphere of the aesthetic process and aesthetic experience. They should never be used as primary foci for evaluation and measurement in art education. Meaningful learning in the arts must be understood as turning upon an increasing responsiveness to and command of design functioning as a carrier of emotional values, in one or all of the three modalities of production, reproduction, and enjoyment, or to use the more familiar but less exact terms, creation, performance, and appreciation. This must be the focus for all significant and valid criteria and procedures, a discussion of which now follows.

In the light of the argument just presented, it appears that art education in all fields and at all levels should be determined by the following primary objectives.

1. To elicit and develop discriminating emotional responsiveness in connection with artistic undertakings of all kinds and in all modalities.

2. To elicit and develop an individualized and personal quality in the learner's responses and in all his work.

3. To elicit and develop the ability to utilize and respond to form in works of art, not as an isolated factor to be studied and classified independently, but as an expressive vehicle.

4. To elicit and develop a discriminating sensitivity to the medium in which the aesthetic design is fashioned.

5. To elicit and develop personal satisfaction in the aesthetic process itself, in all of its three modalities.

6. To elicit and develop a wish to share with others aesthetic experiences and achievements, and to find satisfaction in their responses to one's own endeavors.

Criteria for Measurement and Evaluation

These objectives, around which a program of art education committed to the promotion of aesthetic understanding should be organized, should also serve as the controlling criteria for measurement and evaluation.

1. Evidences of distinctive emotional response are highly significant. When any individual, child or adult, undertakes to paint a picture, to compose a piece of music, to write a poem, or to engage in any other type of artistic production, he should first and foremost be acquiring a selective sensitivity to emotional values. This is intangible and hard to define, yet by no means impossible to observe with reasonable certainty. The individual choice of a theme and the extent to which the theme compels and commands the worker are highly significant indications. Instances might be a child's love for animals, for the circus, for war themes as appearing in his picture-making, his music-making, his poetry, and so forth.

Again, when any person, child or adult, undertakes to engage in any type of artistic reproduction, he should first and foremost be acquiring sensitivity to the emotional values of the art work concerned. His choice of a poem to read aloud, or of a musical composition to sing or play, his selective preference for it as against alternatives, his enjoyment of it expressed in words or actions, his awareness of its distinctive mood, his endeavor to project that mood which of course includes his willingness to study it faithfully, are all significant signs of true artistic understanding.

Similarly in listening, looking, or silent reading for the sake of enjoyment, the important indications are those of the authentic emotional reaction brought about—the individual's choices and rejections, his facial expression, his comments, his silences, his wish to repeat the experience or to enjoy similar ones, the trouble he takes to do so, his recollection of the experience after a lapse of time.

2. Manifestations of individual and personal quality in a learner's responses and work are highly significant. Painting, sculpture, music,

or poetry produced according to a stereotype cannot well lead to artistic understanding. While no definitive classification of psycho-aesthetic types has yet been made, it is highly probable that such types do exist. Some individuals seem predominantly objective, others predominantly visual, haptic, or imaginatively fantastic. Such persons must work and learn in terms of their own unique and distinctive qualities if they are to achieve genuinely meaningful learning. Such differences reveal themselves most clearly in visual creation, less definitely in poetic creation, and least definitely of all in musical creation, but they are probably present throughout. The teacher should consider their progressive emergence and persistence an important sign that genuine aesthetic understanding is developing, and their failure to emerge as a sign that it is not. He should, in other words, look for and set high value upon evidence of individuality in the processes and work of his pupils.

In appreciative responses, too, differences in individual type manifest themselves. Thus, it has been suggested that appreciative responses may be classified as objective, intrasubjective, character-wise, and associative. Some persons make a purely emotional and almost formless response to an art work, others react to its form, its sensory content, its "story" suggestions, and the like. The attempt to reduce appreciative response to a stereotype certainly hampers meaningful experience. On the contrary, the teacher should here again regard the emergence and persistent manifestation of a distinctive type of appreciative response as an indication of growing artistic understanding.

3. Responsiveness to form is yet another significant sign to be noted and heeded in measurement and evaluation. The primary consideration is not the classification of a work of art according to some predetermined aesthetic type—as a sonata, an air with variations, a sonnet, a ballad, a Gothic building, an impressionist picture, or the like. The essential point is to be aware of how the living pattern actually serves and functions as a vehicle for making manifest an emotional intimation. The distinction is that between formal and functional pattern, which is fundamental in both aesthetic theory and educational practice.

Thus, at the beginning, a child may express his emotional reaction to a fire simply by a free use of scarlet, but later on he may wish to organize his picture so as to make clear that it is the values of fire rather than perhaps of war or murder that are to be conveyed. At the beginning a child may express his happiness over the freedom of a summer day by a very simple and almost incoherent pattern of words, but later on come to use refinements of rhythm and imagery to express

with more precision and discrimination what he has to say. A child's early experiences in creating, performing, listening to music may well be simple enterprises in utterance or enjoyment, but later on he may wish to employ or respond more adequately to the resources of nuance and structure to make both utterance and enjoyment more satisfying. Here are instances of the acquisition of control over significant or functional pattern. The teacher should pay very serious heed to all such manifestations, for they are extremely important evidences that meaningful learning and artistic understanding are in fact progressing well. The child's work should not in the first instance be judged in terms of its approximation to the laws of visual perspective, or of some fixed verse form, or of musical structure, for these are primarly formal rather than functional considerations.

4. Sensitivity to the medium being used is yet another significant indication of the presence and advance of artistic understanding. The essence of the aesthetic process is the use of a sensory medium to convey emotional values. Thus, sensitive and discriminating responsiveness to the medium is a very important indication of meaningful learning, although what is involved is by no means eye-training or ear-training as isolated undertakings. Evidence should be noted of the child's responsiveness to color and form in his environment, as manifested in his comments, reactions, choices and uses of color and form in his own work; of his responsive awareness of the sound, rhythm, and shaded meaning of word-patterns; of his responsive awareness of tone-quality, rhythm, harmonic content, and tonal relatedness in music; of his responsive awareness of verbal, visual, and auditory imagery. All these are highly significant signs of meaningful learning and authentic artistic understanding.

5. Personal satisfaction in the aesthetic process itself is another such sign. The aesthetic process, authentically experienced, is exceedingly satisfying and compelling, and may readily become almost obsessive. Evidence of such compelling and commanding intrinsic interest is an important sign of artistic understanding of an authentic kind. Does the child, on his own initiative, seek to compose music, to paint pictures, to write poetry? Does he, on his own initiative, seek opportunity to listen to music, to read poetry, to look at pictures? Does he manifest an intrinsic interest in the aesthetic phenomena of everyday life? Does he show an eagerness to devote time and effort to developing his artistic capabilities? Does he react strongly and positively, in word and action and attitude, to opportunity for creation, performance, and appreciation as furnished by the school program? Do his aesthetic interests and concerns have a priority over competing

interests and concerns? These are the kind of questions the teacher should have in mind in seeking to evaluate the authentic meaningfulness of the learning which is taking place and the understanding that is being built up.

6. A wish to share aesthetic experiences and achievements and an interest in the responses of others to one's own endeavors is yet another significant sign. The aesthetic process is one in which personal and private emotional values and intimations are made objective—that is to say, public and communicable. It is true that the artist does not work primarily to please his audience, but sincerely to convey his own intimations as perfectly as he can. But the vital meaning of his whole enterprise is to say something to somebody. It follows, therefore, that when this is a conscious desire, and when there is a delight in fulfilling it, authentic aesthetic understanding is indicated. Also the artist, whether child or adult, is deeply and legitimately influenced by a sympathetic response to his message. Does the child wish to compose, to write, to paint, to play, to sing in order that others may listen, look, read, and in so doing enjoy and understand? Does he enjoy artistic enterprises at least sometimes in collaboration? If he does, this is genuine evidence of meaningful learning and authentic aesthetic understanding.

In closing it should perhaps be pointed out that these criteria for measurement and evaluation can be embodied in objective testing instruments only to a limited extent. Nevertheless they impose a reasonably definite orientation. They involve such techniques as anecdotal records, logs of pupil behavior, and the like. Properly and intelligently used, they can enable the teacher to isolate and observe decisive indications that the kind of learning desirable in the arts is or is not taking place.

Illustrative Procedures for Evaluation

Graphic and Plastic Art

Explaining the effect of a painting. In a class discussion children were comparing the work of different pupils. It had been made clear that the purpose of comments and questions was to be constructive. Larry's painting, fastened to a board where all could see, was the topic.

"I like the way his picture makes me feel that it is a cold day," remarked Mary. (Larry's picture dealt with two boys making a snowman.)

"I like that too," said the teacher. "How did he give us that feeling?"

"The snowman makes you feel cold," was Jim's answer to the teacher's question. Then, in succession came the following remarks:

"Just seeing a snowman wouldn't give you that feeling. I think it's the color he's used. There's a lot of blue and gray which makes me feel cold."

"I believe it's the mittens and sweater. The boys look all bundled up."

"There is much more cool color than warm color so that the little bit of red in the scarf makes the blues and grays seem all the colder."

That almost-spontaneous remarks such as these are good evidence of understanding goes without question. It should be noted that this type of measurement does not require each child to respond with the one "correct" answer to some described test situation. In fact, only a few pupils were able in the situation described to show that they understood. However, through use of such informal measurement procedures in one class period the alert teacher can gather much evidence of understanding.

A clothing-selection test. This test consists of sets of pictures with a specific question relating to each. Several are described here.

(*a*) Three blouses and one skirt are pictured (all in color). The problem for the pupil to solve is stated in this question: "Which blouse should Sue wear with her plaid skirt?"

(*b*) Four pair of socks and a man dressed in a brown tweed suit, tan shirt with a brown figured necktie, are pictured. The following question was provided: "If you were Tom, what socks would you choose to wear with the clothes he is wearing?"

(*c*) Mary's favorite clothes are pictured on one page; on another are six samples of cloth. The problem is stated as follows: "From the samples above Mary wishes to choose material for a winter coat which she could wear with all her favorite clothes pictured on the opposite page. Which would you choose?"

Through use of colored pictures such as those described above many situations can be presented in a rather short period of time. The use of actual clothing frequently presents better test situations, but the task of securing and handling such materials is rather difficult. Teachers frequently get further evidence of understanding from such tests by asking the students to tell *why* they think the combinations chosen are the most appropriate. Similar tests may be given which cause children to choose luncheon cloths which would be appropriate with different kinds of dishes—white, plain-colored, and patterned cloths may be combined with white, plain-colored, or patterned dishes.

Study of student work. Drawings made at the beginning of the year (also paintings and designs) are compared with those made near the end of the year. In determining the degree of understanding exhibited, the following qualities should be considered:

(*a*) Effective organization or composition.
(*b*) Expressiveness, originality.
(*c*) Technical facility (draftsmanship, use of medium).
(*d*) Suitability for purpose.
(*e*) Acceptability for an exhibition such as the Iowa High School Art Exhibition.

The growth of the pupils during the year as shown by comparison of drawings made at the beginning of the year with those made at the closing of the year is good evidence of understanding.

Analysis of pupil responses. The following questions may be helpful in obtaining evidence of understanding in the field of art. These questions could be employed as items in a rating scale, with three or more categories (such as: poor, average, good). Records of these ratings, made from time to time, afford a useful basis for determining growth in understanding with respect to various types of outcome.

(*a*) Do the children enjoy their art work?
(*b*) Are they observant of the appearance of things?
(*c*) Are they original and independent in their expressions?
(*d*) Do they communicate ideas clearly in drawings?
(*e*) Are they able to criticize their own work and profit by the criticisms of others?
(*f*) Do they see art in everyday living?
(*g*) Do they show an understanding of basic principles of organization-emphasis, repetition, balance, etc?
(*h*) Are they making good choices?
(*i*) Are they able to organize forms suitably for given purposes?
(*j*) Is art functioning in their activities outside of the art class?

Evaluation of cover designs. The preliminary sketches of cover designs were placed on the bulletin board, class discussion of the problem having stressed the following design principles: unity, dominance, repetition.

Child A: "I think my plan has too much in it. People should see right away that it's a gym demonstration."
Teacher: "How would you change your plan?"

Child A: "I think I'll make the words 'Gym Demonstration' the center of interest and put in just one or two figures instead of so many things."

Child B: "I don't think my design is well spaced. The parts don't seem to belong together. I should make the picture and the lettering fit together better."

Child C: "My letters are too crowded to read."
Teacher: "Yes, we must always remember that lettering must be clear."

Music

Class discussion of music problems. After part of a song had been sung the teacher said:

"Class, that did not sound so very well. What do you think we could do to improve?"

"I think that last should be sung more softly."

"Let's try it that way." After the trial the teacher asked, "How about it, John? Was that better?"

"I liked it better. It made me think we were finishing the thing in the right way," was John's answer.

Such answers and comments about songs provide the teacher with good evidence of pupil understanding. It should be noted that such situations furnish opportunity for only a few members of the class to respond and that records of such responses are difficult for the busy teacher to make. On the other hand, a test situation such as this is an integral part of teaching, and, therefore, time used for this purpose can be easily justified. The records of this type of testing can probably best be made at the close of the class period or school day. While not all such test situations should be recorded, it is important that a few be kept.

Observation of pupil attitude. The attitude and reactions of children while singing, playing instruments, and listening to music are good indications of their understanding. The following are specific examples of the type of evidence presented:

(*a*) A class had just finished singing "Home on the Range" and had started "Camptown Races." Several pupils straightened their shoulders, suppressed smiles appeared on the faces of many, and the laughter in their eyes showed that they were "in tune" with the spirit of the music.

(*b*) While listening to a quartette of twelve-year-old girls, one of the children in the room unconsciously put his hands to his ears when the voices did not blend well.

(*c*) In listening to a recording of "Ole Man River" the faces of children showed in succession, feelings of admiration, wonder, and sorrow; then a sort of exultation.

Observation of pupil reaction when performing for others. Three boys who sang solo parts in the "We Three Kings" for a Christmas program practiced during the noon hour. The music teacher later permitted them to rehearse during the music class period. When singing for the class, the attitude of the three boys was markedly different from that they exhibited when practicing during the noon hour. They were conscious of the audience, seemed to sense that their efforts were

being well received. This being "in tune" with their listeners is evidence of understanding.

Record of participation in music. Jim, a student in junior high, was reprimanded in music class in the following manner:

"Why aren't you helping today?"

"I don't like music," was Jim's reply. The teacher noticed during the year that Jim attended orchestra and band concerts voluntarily. One day she said, "Jim, you said you didn't like music and yet I see you at orchestra and band concerts."

"Oh, I like that," was Jim's answer. "I just don't like school music."

Further discussion disclosed that it was the type of songs used in class and not just school music that Jim disliked. The record of Jim's participation was taken as evidence of Jim's understanding and so used by the teacher.

Children's choice of musical selections. A fifth-grade class in preparation for a minuet program (traditional fifth-grade program) had chosen as their subject, "Musical Moments with Mozart." They decided to write and enact a play of the life Mozart lived, featuring, as indicated in the title, the high lights in his musical life. The discussion concerning the selections to be used and the most appropriate place for each gave many opportunities for showing understanding. Two are given here.

(*a*) The children found no record of the selection Mozart and his sister used when playing for Maria Theresa. Excerpts from the "Magic Flute" were used even though Mozart did not write it until years afterward. The children said, "It would have been appropriate to play for the Queen, and since we don't know what was played we probably wouldn't have the right one anyway."

(*b*) These children had learned to sing the "Second Minuet." They wanted to use it in their program even though it was not written by Mozart. They decided to use it as an introductory number preceding the play, for, they said, "After all, Mozart wrote the most famous minuet. This is a good one. It will be a good way to lead up to our play."

Pupil evaluation of performance. The pupil's emotional reaction to his own performance frequently gives evidence of aesthetic understanding.

(*a*) Dan, a fourth-grade boy, cried at the close of his instrumental music lesson. When questioned by his teacher he said, "I played much better last night. I could do that second part well. This morning I can't get it right."

(*b*) Sarah was asked by her teacher how she was getting along in the

orchestra. She replied, "Not too well. We just don't seem to be able to play well together. We can't seem to put real quality into our work. I practice a lot and seem to be able to do the parts, but when I play with the others something seems to be wrong."

(*c*) Two boys talking in the corridor were discusssing the assembly program. One said, "Boy, our orchestra was really hitting. That's the best we have done this year. We have never played that well before, even at rehearsal."

CHAPTER XI

THE MEASUREMENT OF UNDERSTANDING IN HEALTH EDUCATION [1]

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There is considerable agreement in the literature with reference to the major objectives that *should* be attained through health education. The extent to which these objectives *are* attained is dependent on a number of factors. These include: the environmental conditions and public health procedures which influence the individual's surroundings, and the extent to which medical, dental, and other health services are actually available, as well as his own health practices, his attitudes, and his understanding.

[1] The following persons assisted in the preparation of this chapter: Edna Bailey, Professor of Education, University of California; Marion Cranmore, Teacher, Ann Arbor, Michigan, Public Schools; Mayhew Derryberry, Chief, Field Activities in Health Education, U. S. Public Health Service; Marguerite Evans, Teacher, Ann Arbor, Michigan, Public Schools; Ruth Grout, Associate Professor of Education and of Public Health, University of Minnesota; Howard Holland, Teacher, University High School, Ann Arbor, Michigan; Ella E. McNeil, Professor of Public Health Nursing, University of Michigan; Edgar Martin, Teacher, University High School, Ann Arbor, Michigan; Harold E. Mitchell, New York City Health Department, New York; Jay B. Nash, School of Education, New York University, New York; Helen Platt, Principal, Eberbach Elementary School, Ann Arbor, Michigan; Arthur Steinhaus, Professor of Physiology, George Williams College, Chicago; George M. Wheatley, Assistant Vice-President, Metropolitan Life Insurance Company, New York; Pauline Brooks Williamson, Chief, School Health Bureau, Metropolitan Life Insurance Company, New York.

Teaching boys and girls so that desirable outcomes in health will be achieved is the responsibility of teachers, administrators, health specialists, and other adults who share with parents the guidance of youth. Teaching should stress participation in purposeful activity which gives practice in solving the health problems of immediate concern in living. Helping individuals emotionally to accept desirable health practices and motivating them to action are likewise basic. The individual may be said to have attained health objectives which involve understanding when he *behaves intelligently,* that is, according to recommended standards or practices in various common as well as novel situations. Health practices, skills, attitudes, and knowledge are all related to understandings.

Various methods of appraising progress toward the achievement of health objectives have been tried. Much remains to be done to determine the extent to which different procedures do assist the teacher. To extend the successful practices of a number of teachers by influencing many others to try them is one way of testing the applicability of these procedures.

The list of objectives generally considered desirable for health education at all levels, as presented here, excludes all items related to manners and aesthetics. There has been a tendency to include as health objectives such items as care of the clothing, being courteous, neat, cheerful, and a good sportsman. As a consequence, these latter have sometimes been given more attention than such basic items as sleep, rest, exercise, proper diet, and freedom from infection. Likewise, the special objectives relating to mental and emotional health are not listed here, because it is assumed that most of the general objectives mentioned are connected more or less directly with emotional or mental health.

In the area of health education it is generally agreed that behavior and attitudes are of greater importance than is knowledge. Knowledge of desirable practices with reference to health does not necessarily mean that behavior and everyday living are affected positively. On the other hand, failure has often resulted from our traditional teaching of health because insufficient emphasis has been placed on understanding the values of positive behavior and good health habits. The problem of teaching, then, is to help the pupil at each succeeding stage of development to improve his understandings and to increase his emotional acceptance of proper health behavior in everyday living.

The objectives are grouped under (*a*) individual health, (*b*) family health, and (*c*) community health, on the assumption that a good program in health education will assist boys and girls to acquire under-

standing with reference to all of these areas. The overlapping of objectives which appears is intentional and is employed as one means of giving emphasis to certain items. Some of these objectives are less likely to be applicable to the elementary- than to the secondary-school level, particularly if the pupil is expected to verbalize or generalize experiences that demonstrate his understanding of them.

Objectives of Health Education

With Respect to Individual Health

1. To know that every individual has a definite responsibility for his own health and must accept this responsibility if he would achieve his aims most fully, and that the way he lives is important to his personal health and to the attainment of his life goals. He should, however, be aware of the fact that health is not a responsibility he carries by himself as an individual alone, but one which he shares with all members of his social groups.

2.* To know that physical health is so closely related to mental and emotional health that a clear separation between them cannot be made; and to accept the idea that keeping one's self in good physical health enables one to meet the mental and emotional crises in everyday living more successfully.

3. To know how to organize time to provide for balanced living twenty-four hours of the day.

4. To know the relation of adequate sleep and rest to the physiology of tissue functioning and fatigue, and to accept the fact that adequate sleep and rest each day is essential for counteracting the undesirable effects of fatigue and for promoting normal growth.

5. To know the importance of a quiet and restful environment in contributing to the best conditions for relaxation, rest, and sleep, and to know how to provide such an environment.

6. To know how to participate in play and exercise and to accept the fact that vigorous play and exercise, out-of-doors when possible, are important for good bodily function, and that the kind and amount of exercise desirable for different age and sex groups vary with the individual.

7. To know that it is through suitable strenuous physical-education activities, exercise, and play, that one acquires endurance, strength, stamina, i.e., the physical power to achieve difficult tasks, and to know

* Objectives marked with the asterisk are applicable primarily to the secondary school.

the relationship of this ability to physical fitness and the factors that contribute to total body fitness.

8. To accept the fact that it is important to be able to get along with others in work, play, and other social situations.

9. To know the physiology and mechanics of the skeletal and muscular systems, the means to develop and maintain good posture, and the relationship of body mechanics to personal appearance, nutrition, and fatigue.

10. To know how the various kinds of food function in the human body, how to obtain these foods, and how to improve his own habits of eating and food selection, and to accept the fact that a well-balanced daily diet is essential for his best growth and health.

11. To understand the importance of the sanitary handling and care of food for one's self and others.

12. To know the importance of cleanliness as a factor in improving individual and group living and in preventing the spread of disease.

13. To know the need for and the essentials of a good periodic appraisal of one's own health status, and to understand what the individual, teacher, parent, and health specialists can do in making such an appraisal.

14. To know the importance of getting defects corrected early, as well as the importance of early medical attention for illness and the means of obtaining the full benefits of the facilities available.

15. To know the health needs and problems of his own and other social groups and to understand what the individual can do about them.

16. To know that immunization makes it possible to be protected against certain diseases, and that it is a mark of good citizenship to seek such protection.

17. To know that communicable diseases are due to specific germs (micro-organisms or viruses) and that every individual can do certain things to avoid and to prevent the spread of these diseases.

18. To know that the common cold is a communicable disease, that the symptoms usually associated therewith are frequently the same as those associated with other communicable diseases, and that mingling with others when one has a cold is subjecting them to the risk of infection.

19. To know the importance of using individual drinking cups, towels, wash cloths, toothbrushes, combs, and other personal articles.

20. To accept the fact that in a democracy all pupils must share responsibility for the proper use and care of sanitary facilities in the

school and for the maintenance of healthful living conditions within the classroom.

21. To know that drugs and treatments are a valid part of medical practice, but that in the hands of the layman they may prove dangerous; that self-diagnosis and self-medication in time of illness are unwise and sometimes disastrous.

22. To know how to prevent accidents and how to give first aid in case of accident, and to understand the importance of emotional control in case of injury or other emergency.

23. To know the nature of the human organism, its general and variable characteristics with reference to normal growth and development, and the physiological effects of wholesome and unwholesome practices of daily living.

24. To accept the fact that individuals with handicaps such as limited vision, blindness, hardness of hearing, deafness, orthopedic defects, or speech impediments should be helped to adjust to these conditions and to obtain the type of supervision that will make them useful members of society.

25. To know the structure, physiology, and purpose of the special organs such as eyes, ears, nose, throat, mouth, and teeth, their economic and vocational values, and the methods of caring for these organs.

26.* To know the role of heredity in health, the principles of genetics and eugenics, and their application in improved human relationships. This knowledge includes understanding of the structure and physiology of the sex organs, the nature of wholesome relationships with members of his own and the opposite sex, and means of improving those relationships through social activities, sports and games, group work, and other experiences.

27.* To know that scientific information is available concerning the effects of alcohol and tobacco. He should know where to find such information and why temperance is desirable, and should accept the concept that temperance *in all things* is essential for balanced living.

With Respect to Family Health

28. To accept the fact that the health of a family is dependent on the healthful or unhealthful living of each individual composing the family.

29. To know the family health services available through the local health department, visiting nurse association, hospitals, private physicians and dentists, or other health agencies or personnel in the community, as well as the desirable procedures for selecting, obtaining, and using these services.

30.* To know the principles and procedures for the home-care of various age groups subject to illness or accidents, and the precautions that help to prevent both illness and accidents.

31.* To know the principles of child care, "growing up," and preparation for marriage, as well as their relationship to the establishment of one's own home.

32. To know how to improve environmental health conditions with reference to light, heat, ventilation, and sanitation within the home and on the home premises, and to accept a share of the responsibility for making these improvements.

33. To know the importance of checking consumer advertising of medicine, foods, and treatments before purchasing the product for use by any members of the family.

With Respect to Community Health

34.* To know the major health needs and problems of the community and the means of assisting professional and lay groups in finding these needs and in making plans for community health improvement.

35.* To know the financial burden placed on the community through unnecessary sickness and death, and the means by which the individual can assist in reducing this economic waste.

36.* To accept the facts that public health laws, procedures, and programs are designed to protect the health of citizens in the community and that individuals have a responsibility to co-operate in their enforcement.

37.* To know the health advancement which has been made in modern times for the improvement of individual, family, and community living and to recognize the importance of individual responsibility in preserving this heritage and contributing within his own ability to further advancements.

38. To accept the principle that it is important for the school, the home, and community groups to co-operate in the effort to improve the health program for the total community.

39.* To know the occupational hazards and the health problems of industry in his community, as well as the means for dealing with them, and to accept the fact that health is important to job-getting and job-holding.

40. To know how to make his community safe with reference to the prevention of accidents due to traffic, fire, drowning, or other hazards.

Illustrative Procedures for Evaluating Understanding in Health Education

General procedures for evaluating the extent to which health-education objectives are attained are similar for both the elementary and the secondary school. The emphasis given to the various procedures and the specific devices used will vary. In this section of the chapter the aims are: (1) to list typical general procedures and (2) to present examples of how these general procedures, accompanied by specific devices, may be applied in estimating the extent to which various objectives are attained. It should be pointed out that no one general procedure or specific device can completely measure understanding as expressed in even *one* of the objectives. Several different procedures and specific devices which supplement each other will give a more perfect measure than any one used separately. The procedures and devices presented are usually applicable to more than one objective; likewise, each objective can and should be evaluated by several different methods.

It should be pointed out further that the manner in which the general procedures and specific devices are used is more important than the procedures or devices themselves. The best tools are ineffective instruments in the hands of the unskilled worker. The "measurement of understanding" demands thoughtful and careful use of the tools just as does effective teaching. Indeed, some of the methods suggested could be employed as teaching aids as well as for evaluation purposes.

General Procedures

The general procedures which are most useful for evaluating understandings in health education may be grouped as follows:

1. Observation of pupil behavior and the recording of these observations in behavior journals, in anecdotal records, or in other ways.
2. Self-appraisal by the pupil in terms of standards of behavior previously agreed upon.
3. Check lists and survey forms based on accepted "standards" and used at periodic intervals.
4. Interviews with pupils, parents, other teachers, and community workers, including home visits and individual counseling.
5. Health-examination records and reports from physicians, dentists, and nurses.
6. Reports from local physicians, ophthalmologists, and dentists regarding the increase in medical and dental supervision of school-age groups.

7. Diaries and other autobiographical records of pupils.

8. Specially created situations within the classroom and school which give pupils opportunity to apply voluntarily what they have learned.

9. Paper-and-pencil inventories aimed at application of principles and evaluation of sources of help.

10. Expression of pupil opinion which considers positive health behavior the "thing to do," because the natural leaders in the school have accepted it.

11. Records of the sale of milk, salads, fruits, whole-grain cereals, enriched bread, etc., in the school cafeteria or in local food establishments, including dairies and stores.

12. Samples of pupil creative work, such as drawings, models, exhibits, photographs, motion pictures, or written and oral reports which show sound application of health principles.

The literature of education and health contains some references which furnish concrete illustrations of how these general procedures have been applied to specific situations. Some of this literature is referred to in the following section. It has been impossible to avoid considerable overlapping of objectives and of ways to evaluate them, but this overlapping is viewed as desirable.

Suggested Procedures for Evaluating Understanding in Elementary Grades (Kindergarten through Grade VI)

The procedures here described should be started in the kindergarten and continued through the sixth grade by *all* teachers. They constitute one means of insuring individual pupil responsibility for sound health practices.

Objective 1. Responsibility for own health. Accumulate anecdotal records at periodic intervals to be compared with other observations made of the same children; conduct informal "morning inspection" to determine whether children need to be reminded of personal hygiene delinquencies; make comparison of inspection records from time to time to note progress; encourage pupil self-appraisal of personal appearance and hygiene to determine if children are ready to begin the school day; collect pictorial reminders made voluntarily by children and posted in the classroom; examine reports of parents, church, and youth leaders from time to time.

Objective 3. Organize time for balanced living. Observe the extent to which children assume increasing responsibility for planning a balanced day in school by participating in rest, play, lunch, and work

periods with decreasing assistance from the teacher. Observe if children rest when they are tired, play with others during recess, eat their lunch at noon, and engage in work activities at the times assigned to them. Note improvement in the practices of individual children and record these observations in behavior journals. Determine through reports from parents similar growth in responsibility in home activities.

Objectives 4 and 5. Rest, sleep, and environment. Observe the extent to which children contribute to the creation of a quiet environment during rest periods in school and the manner in which they rest. Compare results of observations at periodic intervals. Through interviews with parents determine whether children go to bed willingly, give up radio programs that may interfere with their sleep, and obtain regularly the hours of sleep recommended for the age group.

In interviews with camp counselors, obtain evidence as to understanding of the need for rest shown by the pupil in a camp situation. Compare these reports with records of school and home behavior.

Questionnaires and voluntary reports from parents are described by Hardy and Hoefer (**8**: 65-66); and use of the questionnaire, covering such items as going to bed early, drinking milk, keeping self clean, etc., by Turner (**18**: 50-52, and chap. iii).

Objectives 10 and 11. Balanced diet and sanitary handling and care of food. Determine changes in food practices through periodic pupil reports such as "What I ate yesterday." Discover through posters showing well-balanced meals and through notebooks, exhibits, menus, or plans for refreshments for a parent-day or children's party, as classroom activities, the extent to which pupils *seem* to understand the value of healthful food. Observe what children eat for their lunches at school and discover improvements in selection of food and manner of eating it. (Consider lunches in relation to breakfasts and dinners.) Observe improvements made by children in the handling of foods, e.g., the morning milk and the steps taken to keep food sanitary.

Determine through periodic "taste-it activities," the foods children like and dislike. Note the extent to which individuals taste and then eat foods they express dislike for.

Self-appraisals by children may include questionnaires based on "What I Usually Do"; "What I Did Today or Yesterday," as well as informal reports by children on how they think they have improved their health practices. Sample lists of questions are illustrated in **7**: 46-47, and in **2**: 167. Questionnaires, too, may discover whether pupils apply what they learn. (See also **5**: 136-37.)

Objectives 13 and 14. Periodic health examinations and correction of defects. Through the use of daily observation and periodic screen-

ing, identify children that have improved their health status. Discover through interviews or correspondence with parents, physicians, and nurses, and through reports from physicians, dentists, or nurses what physical defects or other adverse health conditions have been corrected and whether the children are examined at periodic intervals by their family physician and dentist.

Reports of medical, dental, and orthopedic rechecks by physicians, dentists, and other professional personnel provide clinical evidence of understanding. Sample accounts for elementary-school children are included in **8**: chap. iii. Items for teachers to observe in physical examinations and screening tests are suggested by Rogers (**14**); and helpful forms for teacher observation and for physicians' examinations are provided by Nyswander (**12**: 64-65, 134-35, and 337).

Objective 15. Health needs and problems. Through the comparison of environmental health conditions of schoolrooms and grounds with recommended standards at periodic intervals, determine the healthfulness of surroundings and steps taken by children to improve unhealthful conditions. Follow a similar procedure in determining health problems and needs of various age groups. The following references, which suggest items for inclusion, are especially helpful in this connection: **7**: chap. iii (particularly applicable to elementary grades), **3**: 208-11, and **11** (procurable from state or local tuberculosis associations). Closely related to these inventories is the Strang and Smiley "Teachers' Inventory of Their Health-Education Activities" (**17**: 343-47), which, besides providing a means for analyzing the teacher's health program, includes questions relating to children's behavior and their health attitudes in the classroom and school environment. The interested reader should also examine reference **14**.

Objectives 16, 17, 18, 19. Immunization and prevention of communicable diseases; the common cold. Determine through a study of attendance records the illnesses that keep children at home and whether the introduction of a health-instruction program effects any change in the number or duration of absences for individual children and for the group.

Observe and record from time to time the behavior of children with reference to sneezing, using a handkerchief, putting things in their mouths, and using drinking cups and other personal equipment. Compare with accepted good practices and note changes in behavior.

Through interviews with parents or with the public health nurse, identify the children who have been immunized against small pox, diphtheria, and other communicable diseases. Compare the number with the record of former years. Study the reactions of children

toward immunization when it is done at school. Note whether there is evidence of a greater acceptance, understanding, and interest on the part of parents and children than formerly.

References included under Objectives 1, 2, and 3 above and under Objective 24 below are applicable here, as also are those given under Objectives 4 and 5.

Objective 22. First aid and prevention of accidents. Determine the experience children have had in giving first aid. Compare this experience with recommended practices. Keep a record of the injuries children report and note whether they show increasing recognition of the conditions which require the exercise of care.

Ask safety patrol members to record violations of safety rules, and compare their records from time to time to note evidence of improvement.

Through a record of accidents in the neighborhood or at home, with suggestions for their prevention, determine improvement following safety instruction. The record might include date, nature of accident, how it occurred, where, when, extent of injury, and how it could have been prevented.

Study the safety practices of children, such as use of scissors, throwing stones, leaving materials and equipment where they may cause falls, and note improvement throughout the year.

Observe the reactions of children when they are slightly injured. Do they exhibit good emotional control? Do they cry less easily? Do they show less anger?

Reference 1 (chap. iv) is useful in this connection. Also, the National Safety Council (20 Wacker Drive, Chicago 6, Illinois) has a number of instruments of value: "Are You Doing Your Part?" (a self-check device), "Keeping Accident Records," and "Tests in Safety Education" (the last-named for various grade levels).

Objective 23. Nature of the human organism; physiological processes and responsibility of the individual. Determine through group discussion or individual interviews if children understand variations in growth as expressed in animal or plant experimentation as a normal phenomenon which applies also to themselves and their friends. Determine if children appreciate variations in height and weight gains among their own group through analysis of individual height-weight graphs. Keeping growth records may be made a pupil activity.

Objective 24. Children who are different. Observe pupils' behavior toward children with various handicaps or the children of other races and those of different social and economic backgrounds. Significant

traits are: willingness to play in games which require children to stand next to each other or take hands, willingness to share materials, to help when help is indicated, or to sit at the same table at lunch.

Specific illustrations of some of these suggestions will occur to teachers from their own experience and reading, especially in the area of child growth and development. (See, for example, **15**: chaps. xvii, xxi.) Types of behavior journals and diary reports, for example, are familiar to many teachers. Some writers advocate providing only a plain sheet of paper for each child, recording what is observed from time to time under specific dates. Others rule the paper to include date, incident observed, and comments, such as frequency of incident, what was done about it, etc.

Helpful references are "Teacher Record of Progress" (a three-year record form which children can assist in keeping), **7**: 47-48; **4**, chaps. iv, vi; and Strang's "case-study" type of report in *Every Teacher's Record* (**16**).

Objective 37. Health advancement for community. Determine through creative drawings and exhibits, the understanding of children regarding "Health through the Ages," or the application of modern science to improved living in the community.

Paper-and-pencil tests may be helpful for both of these objectives and also for Objective 15 (**2**: 366-73). Standardized tests suitable for the elementary grades include:

FRANZEN, RAYMOND; DERRYBERRY, MAYHEW; AND MCCALL, WILLIAM H. *Health Awareness Test.* New York: Bureau of Publications, Teachers College, Columbia University.

GATES-STRANG. *Health Knowledge Test,* Forms A, B, and C. New York: Bureau of Publications, Teachers College, Columbia University, 1937 (revised).

ORLEANS, JACOB, AND SEALEY, GLENN A. *Public School Achievement Tests: Health,* Forms 1 and 2. Bloomington, Illinois: Public School Publishing Co.

SPEER, ROBERT, AND SMITH, SAMUEL. *National Achievement Tests: Health Test.* Rockville, New York: Acorn Publishing Co.

Suggested Procedures for Evaluating Understanding in the Secondary School (Grades VII-XII)

Many of the evaluative procedures suggested for the elementary grades are equally applicable to the secondary school, especially Grades VII and VIII. Observation, for example, continues to be of great value, but it is more extensively supplemented by paper-and-pencil inventories and tests in the higher grades than in the elementary school.

Objective 1. Responsibility for own health. Determine through observations made by the homeroom teacher or the first-hour teacher the extent to which students assume responsibility for their personal health. (This practice can be used in connection also with Objectives 3, 4, 6, 12, and 19.) Observations may be followed by individual conferences, when changes in behavior are noted from time to time. (See **4**: chap. vii; **19**: 130-31.)

Ascertain through samplings of student opinion and through observation, especially of natural leaders, whether good health practices are the "vogue," and whether they are considered an important factor in school success.

Health-practice inventories, like that prepared by Ned Johns of Stanford University, and health-attitudes tests, like that prepared by Oliver Byrd of Stanford University, are useful. Consult also **5**: 136-37, and **19**: 135-36.

Reports by pupils of how they believe they have improved in their health practices, or what they think they may have learned from instruction in health, may give evidence as to the degree of understanding they have achieved[2] (**19**: 132-33).

Objective 2. Physical health related to mental and emotional health. Determine the relationship between physical and emotional states from records of absences and complaints of digestive (gastrointestinal) disturbances, headaches, general malaise in school examinations, plays, parties, athletic or musical contests, or other activities which cause unusual fatigue, pressure, or tension. Through individual conferences ascertain the extent to which particular students understand this relationship and do something about improving their regimen.

Analyze student responses to the question, "How grown-up am I in my emotional expressions when things do not go my way?" Compare the responses with check-list standards on "growing up emotionally," which students might help prepare.[3]

Objectives 3, 4, and 5. Organizing time for balanced living; sleep and rest. Determine, through group discussion and individual counseling, the extent to which students understand how to budget their time to allow adequate portions for sleep, recreation, study, and work. Through periodic analysis of pupil reports, such as "How I spent the past twenty-four hours" or "How I spent the past seven days," make

[2] H. H. Giles; S. P. McCutchen; and A. N. Zechiel, *Exploring the Curriculum*, pp. 146-51. New York: Harper & Bros., 1942.

[3] Donald McLean, *Knowing Yourself and Others*, Unit IV. New York: Henry Holt & Co., 1938; Peter Blos, *The Adolescent Personality*. New York: D. Appleton-Century Co., 1941. This reference illustrates the case-study approach.

comparisons to indicate improvement. With the aid of circle graphs which show desirable distributions of time throughout the day or week, have students appraise their own expenditure of time. Collect evidence from parents, employers, and proprietors of student "hang-outs" regarding hours of study, work, and recreation. Note increase or decrease in these hours from time to time. Do the *times* for study, work, and recreation fit into a well-balanced and healthfully scheduled day and week?

Self-appraisal procedures, such as that described by Giles *et al*,[4] and by Weber (**19**: Part II, Unit I, and pp. 135-38) are suggestive. The latter reference contains questions and check lists.

The interview as a means of health counseling is discussed by Leonard (**10**: chap. i); and a series of three personal conferences relating to health, physical development, family relationships, etc., is described in some detail by Weber (**19**: 138-44).

Objectives 10 and 11. Well-balanced daily diet; sanitary handling and care of foods. Determine through a study of sales of milk, soft drinks, candy, fruit, vegetables and salads, in the school cafeteria, local stores, or nearby restaurants whether there has been an improvement in the dietary purchases of students or their families.

Observe periodically methods of food handling and dish washing employed by students working in the food services, and compare with recommended standards; or use student self-appraisal forms in a like manner.

Through analysis of sample records of food eaten daily (amount and type) and comparison with recommended standards, have students appraise their own diets at periodic intervals.

Weber (**19**: 133) suggests types of questionnaire and of voluntary reports from parents to help appraise health practices. The public opinion poll may be adapted as a means to influence pupil behavior,[5] and home economics departments can contribute suggestions also.[6]

Objectives 13, 14, and 15. Health examinations; correction of defects; health problems. Determine the number of students who voluntarily see their physician and dentist at regular intervals to obtain a health examination or to have known defects remedied. Through the periodic use of self-appraisal forms, estimate improvement made in health status, including good personal hygiene. By the use of paper-

[4] *Op. cit.*

[5] Paul Guernsey, "The Modern Public Opinion Poll," *American Journal of Public Health*, XXXII (September, 1942), 159-66.

[6] Clara Brown, *Evaluation and Investigation in Home Economics*. New York: F. S. Crofts & Co., 1941.

and-pencil tests (see suggestions under Objectives 23 and 26) or through individual interviews or counseling (e.g., Leonard, **10**) determine if students understand what constitutes a good health examination, why periodic examinations are important, how they should go about obtaining such an examination and assistance in the correction of revealed defects.

Examine reports of medical, dental, and orthopedic rechecks. Sample accounts for high-school students are included in Weber (**19**: 129-30). Dorothy Nyswander (**12**: chaps. x-xii) offers suggestions for health examination and home environment (see also **7**: chap. iii). Many of the suggestions may be applied to the high school. Further suggestions are found in **3**: 208-11; **11**; and **17**: 343-47.

Objectives 16, 17, 18, and 19. Immunization; prevention of communicable disease; citizenship; the common cold. Determine the number of students who voluntarily exclude themselves from school when they have a cold or other communicable infection, and how many voluntarily participate in a program for finding tuberculosis cases. Determine through paper-and-pencil tests if students understand ways of spreading communicable diseases, special hazards, methods of prevention, the age at which immunization should be given, and the responsibility of the individual for prevention and control of communicable diseases. In physical-education classes and in social situations observe the number of students who wear each other's clothes, use common combs, lipsticks, towels, drinking glasses, etc. Create classroom situations which reveal whether students apply what they have learned, and observe the extent to which they carry over health generalizations from one situation to another. Illustrations are reported in *Science in General Education.*[7]

Objective 24. Individuals who are different. Observe the behavior of students toward those with physical handicaps and those of different races and socioeconomic status, as revealed in willingness to participate together in athletic and social activities, to elect to school offices, to go on excursions in the same group, etc. Laton[8] offers other suggestions in this connection and also demonstrates the value of discussions relating to such problems.

Objectives 23 and 26. Nature of the human organism; physiological

[7] Progressive Education Association, Report of the Commission on the Secondary School Curriculum, *Science in General Education*, p. 434. New York: D. Appleton-Century Co., 1938.

[8] Anita Laton, *Suggestions for Teaching Selected Material from the Field of Genetics*, pp. 35-36. Bureau of Educational Research in Science, Monograph No. 1. New York: Bureau of Publications, Teachers College, Columbia University, 1939.

processes; sex education; and human relationships. Through paper-and-pencil tests determine the extent to which students understand bodily changes during puberty and the nature of normal development.[9] Observe behavior of students in relation to these changes in situations like the swimming pool, shower, and dressing rooms where students see each other in the nude or scantily clothed. Do students exhibit unusual shyness, timidity, curiosity, or concern about their own bodies or the bodies of others? Observe also the behavior of students of varying ability in motor skills, musical, or scholastic ability toward each other. Do they recognize the fact that variations in ability are normal?

Keep a record of the books on sex education, growing up, boy-and-girl relationships, preparation for marriage, child care, homemaking, and similar topics, as these are checked out from the school or public libraries or requested for use in the library. Is the use of these books increasing or decreasing? What types of books are in greatest demand?

Observe the relationships between boys and girls in various informal situations and between high-school students and small children in play and other situations to determine the extent to which good judgment is present. Determine through paper-and-pencil inventories the attitude of students toward others in various social situations. With a basis of knowledge of home conditions derived from a study of students' records, try to discover through individual counseling the attitudes of students toward members of their family and evidence of good or poor relationships within the family. Analyze autobiographical reports of students.

Paper-and-pencil tests may be helpful in determining whether the student *can* apply understandings but do not tell whether he actually *does* make the application in daily life. The types of paper-and-pencil tests most useful in evaluating understanding are essay-type, involving the application of principles and interpretation of data, as well as master-list test forms. Samples of each of these with items related to health education are included in Weber (**19**: 125-30) and in *Science in General Education.*[10]

Health inventories related to information, practice, and attitudes may indicate ability to understand when items are parallel and responses to the items are consistent. Pertinent suggestions are presented in the *Health Inventories.*[11] Sample tests for elementary-grade chil-

[9] Alice Keliher, *Life and Growth.* New York: D. Appleton-Century Co., 1938; Caroline Zachry, *Emotion and Conduct in Adolescence,* chap. ii. New York: D. Appleton-Century Co., 1940.

[10] *Op Cit.,* pp. 427-34.

[11] Co-operative Study in General Education. Chicago: American Council on Education (5835 Kimbark Avenue).

dren are found in **6**: 286-88; and a comprehensive list of the more traditional paper-and-pencil tests appears in **2**: 370-73.

Other paper-and-pencil tests that will be helpful include:

Tests by Byrd and Johns referred to under Objective 1.

GILL, E. M., AND SCHRAMMEL, H. E. *Gill-Schrammel Physiology Test.* Emporia, Kansas: Kansas State Teachers College.

NEHER, GERWIN. *Health Inventory for High-School Students.* Los Angeles: Test Bureau, Board of Education.

PROGRESSIVE EDUCATION ASSOCIATION (Evaluation in the Eight-Year Study.) *Tests on Application of Principles in Science; Interpretation of Data; Scales of Beliefs,* etc. Chicago: Progressive Education Association (5835 Kimbark Avenue).

TRUSLER, V. T., AND OTHERS. *Trusler-Arnett Health Knowledge Test.* Emporia, Kansas: Kansas State Teachers College.

Objectives 22 and 30. First aid; prevention of accidents and home care of illness and accidents. Ascertain the number of students who have passed the standard course in First Aid, the school course in home nursing of the American Red Cross or its equivalent, and the extent to which students apply what they have learned. Use the "Log" in which applications are recorded and comparisons made from time to time, e.g., "What was learned in class," and "Examples of how it was applied outside of school."

How many students have made a survey of safety hazards in their homes and have done something to correct them?[12]

Organize a bicycle traffic squad and trial court and study the quality of work done by the traffic "officers" and judgments expressed by the jury and court to determine whether safety understandings appear to be improved.[13]

Through a study of accidents in the gymnasium, shops, laboratories, on the school grounds, and on streets, discover ways of preventing or reducing accidents and of increasing student responsibility for doing the same. Aids for evaluating home care of accidents and illness are available through local chapters of the American Red Cross.

Through paper-and-pencil tests and driver tests estimate the ability of the students as safe drivers. (See **1**: chap. vi.) Study student violations of traffic regulations for a number of years to determine improvement.

Objectives 21, 29, and 33. Drugs, treatment; dangers of self-diag-

[12] See check lists of National Safety Council and National Education Association.

[13] The National Safety Council, 20 North Wacker Drive, Chicago 6, Illinois, has suggestions.

nosis; family health services, and consumer advertising. Determine through paper-and-pencil tests the ability of the students to evaluate sources for medical or dental assistance including advertised remedies.[14] Study the written reports of students regarding qualifications for good professional health personnel (e.g., physician, dentist, nurse, nutritionist, physiotherapist, ophthalmalogist, *et al.*). Do students know whether their personal dentists and physicians are members in good standing in their professional groups, e.g., local medical or dental societies?

If facilities permit, compare advertising claims with the findings of experiments in the science laboratories (in school and out) as to what constitutes a good product. Find out whether students check their own practices with reference to the purchase of cosmetics, cold creams, lotions, and dentifrices.

Determine through student committee or individual reports, panel discussions, or other forms of expression the understanding which students have of community resources for health protection, their functions, and the responsibility of the individual for their support. Health inventories suggested above will be helpful; also, those under Objective 26.

Objectives 35, 36, 38, and 40. Consumer advertising of health products; public health and safety. Appraise each student by a study of recommendations he makes for improving public health and for reducing health hazards in occupations after he has made an investigation of public health laws, workman's compensation, and health and safety conditions in the community.

Through student reaction to comparative studies of health conditions during various periods of history and in different parts of the world at present, discover how well students understand their "public health" heritage.

Paper-and-pencil instruments in the form of multiple-choice and identification tests, or of a study of situations, with application of principles, will be useful, as will also debates or essays which provide the opportunity for students to demonstrate how well they can interpret data.

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[14] See *Health Inventories* of Cooperative Study in General Education, American Council in Education, 5835 Kimbark Avenue, Chicago 37, Illinois.

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CHAPTER XII

THE MEASUREMENT OF UNDERSTANDING IN PHYSICAL EDUCATION

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OBJECTIVES OF PHYSICAL EDUCATION

Too many people think of physical education as a means merely for producing skilled performances in athletic contests. While such performances may be desirable outcomes, physical education, properly conceived, includes in its objectives many fundamental understandings about sport, about the human body, and about physical fitness and recreation which are applicable to the whole span of life. Intensive competition lasts only a few years for the small percentage of persons who are athletes and plays a very small part in the education of the larger proportion of the population for whom sports and physical fitness are fully as important as they are for athletes. Physical education is for every man, woman, and child; it is for all ages and should be continuous through life to maintain fitness and to provide enjoyable recreation. The fundamental purposes of physical education are centered on understanding the nature of growth and physical development, understanding the methods of maintaining physical fitness according to individual needs in life, and understanding how to enjoy a lifetime of participation in sport for recreation and fuller living. All along, under good leadership, there are unusual, if incidental, opportunities for character building and personality expression.

In so far as understandings are involved, the objectives of physical education are centered around four main areas. So grouped, the objectives are:

1. *Understandings related to physical fitness:*[1]

To understand the significance of the body-type rating.
To understand why one is overweight or underweight.
To understand the effect of fat on or inside the body.
To understand how to reduce fat.
To understand the causes of poor posture.
To understand how to improve posture.
To understand the relationships of muscular fitness.
To understand how to develop and condition the muscles.
To understand how to develop "wind."
To understand the relations of heart size.
To understand the relations of the trained versus the untrained state of the blood.
To understand the meaning of adequate circulation at various ages.
To understand the relations of physical conditioning to low energy and chronic fatigue.
To understand how to develop circulatory-respiratory endurance.
To understand the causes of poor teeth.
To understand how to maintain good teeth.
To understand the cause of poor complexion.
To understand how to acquire a good complexion.
To understand the causes of poor eyesight.
To understand how to conserve the eyesight.
To understand the adjustments and corrections possible for poor sight or hearing.
To understand the causes of nervousness, temper, and inability to concentrate.
To understand the facts of sexual hygiene, development, and maturity.
To understand the meaning of poor motor ability.
To understand the principal constituents of motor fitness.
To understand how some people have maintained physical efficiency until an old age.
To understand how much improvement is possible at various ages and for different levels of ability.

2. *Understandings related to curriculum and extra-curriculum opportunities to become physically educated:*

To understand the courses or activities most suitable for body building.

[1] This is only a partial list. In greater detail the list might contain a hundred or more items, all of them desirable objectives. Those listed are among the most important, and they will serve to exemplify the kinds of understandings which relate to physical fitness.

To understand the courses or activities most suitable for reducing fat.

To understand the courses or activities most suitable for developing fundamental motor ability.

To understand the courses or activities most suitable for developing endurance.

To understand the courses or activities most suitable for developing aquatic ability.

To understand the courses or activities most suitable for developing self-defensive ability.

To understand the courses or activities most suitable for social recreation.

To understand the courses or activities most suited to a particular physical defect or to a given fitness deficiency.

To understand the courses or activities which are continued longest by the most people for fitness and recreation.

To understand some physical activities for each season of the year.

To understand how much education and work it takes to be "good" in various activities.

3. *Understandings related to social participation through physical education:*

To understand the value of sacrificing self-interest for the good of the team.

To understand why rules must be scrupulously followed.

To understand the place and importance of officials.

To understand the value and dangers of spectators.

To understand the rules of sportsmanship.

To understand how to co-operate with captain, manager, coach, and players.

To understand the value of self-control.

To understand the essential elements in leadership.

To understand the value of being cheerful and happy.

To understand the value of honesty.

To understand the value of relaxation at proper times.

To understand the dangers of jealousy, suspicion, or "talking-down" another person.

To understand the value of play.

To understand how to secure needed guidance in sex and other health matters.

To understand the physical requirements of various occupations.

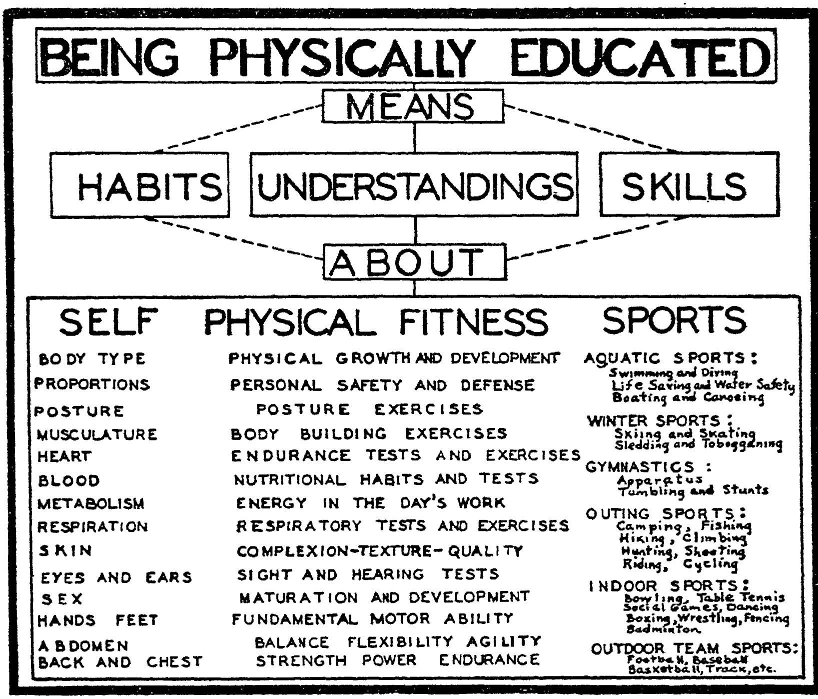
To understand one's self with respect to group standards in physical tests.

4. *Specialized knowledge of selected activities:*

To understand the rules.

To understand the mechanical principles of skill.
To understand the methods of physiological training.
To understand the methods of psychological training.
To understand the kinesiology of movements.
To understand the relations of body type to performance.
To understand the significance of standards of performance.
To understand how long it takes to develop skill.
To understand the factors from which performance may be predicted.
To understand the vocational values of the activities.
To understand the health value of the activities.

The significance of such understandings for physical well-being and their relationship to knowledge, habits, and skills are exemplified in the accompanying chart.



Illustrative Procedures for Evaluating Understandings

Procedures for evaluating understandings in physical education are not as formally organized as in many other fields of education. This lag is due to the emphasis on big-muscle activity and to the spontaneous interplay of personalities among individuals in games and sports. The

direct and certain measurement of understanding is seldom possible, and devices and procedures are only rarely described in the literature.

The methods physical-education teachers customarily employ to determine understanding are:

1. By observing the correctness with which fundamental principles of action (mechanics, psychology, physiology, etc.) are exhibited in performance.
2. By observing the participation of an individual to see that he knows his part in the play with other individuals.
3. By observing the individual's social behavior before, during, and after participation.
4. By observing the choices and preferences of individuals for activity in relation to their apparent or tested needs.

Formal paper-and-pencil tests are *not* generally used by teachers and coaches in their classes because of their deliberate intention to emphasize action and play in ways *different* from the activities of most classrooms. Personal discussion, man-to-man talks, and exchange of confidences mark the daily interchange between players and coach or between teachers and pupils in physical education. Also, physical-education teachers have been discouraged from using paper-and-pencil tests because of the very low correlation found between test scores and rated playing ability. Rightly or wrongly, coaches have accepted playing ability rather than understanding as their principal goal and, in so far as they measure understanding at all, they do so indirectly through their evaluation of playing ability.

With more time available for physical education, knowledge tests, attitude tests, and tests of understanding may become much more generally used. At present, the methods employed to evaluate understandings in physical education may be grouped into four main types:

1. *Simple observation and rating.* Keeping reminders of daily observations, usually recorded by marks and brief notations kept in a diary or classbook or on a grading chart. The teacher judges the performance, the leadership, the co-operation, the talk, and the intelligent or unintelligent reactions of the pupil. Allotted points are usually based on such observations, but also are sometimes subject to vote by teacher and group leaders.
2. *Controlled observations and ratings.* Using systematic rating forms for noting types of behavior which reflect some degree of understanding.
3. *Standardized written tests.* Using standardized knowledge tests or attitude tests, graded by the teacher.
4. *Performance tests.* Using standardized tests in which the performance is regulated partly by understanding, and subjecting the results to discussion and interpretation by the teacher or the coach.

Following are illustrative applications of such techniques to the evaluation of objectives which involve understanding in the field of physical education.

Simple Observation and Rating

a. Monthly rating form for grades. The "Form for Recording Monthly Physical Education Grades" used in the Suffield, Connecticut, schools is presented here to illustrate a procedure whereby the teacher of physical education rates the pupil with respect to various aspects of learning and performance. An agreed-upon system of points may be used, such as 20 for each aspect; or signs *plus* and *minus* may be used for unusual behavior. These records are considered when the teacher estimates a final mark.

FORM FOR RECORDING MONTHLY PHYSICAL EDUCATION GRADES

Department of Physical Education
Suffield School, Suffield, Connecticut

Class____________________ Instructor____________________
Month____________________

NAMES	ATTENDANCE RECORD		Skill	Health Habits	Intelligence in Activity	Spirit and Co-operation	Constructive Leadership	Monthly Grade
	1st Week	4th Week						

The categories in the form, it will be noted, are inclusive—skill, health habits, intelligence in activity, spirit and co-operation, and constructive leadership. Although understanding is specifically measured only in "intelligence in activity," it is indirectly measured as one phase of the complexes represented in the other categories.

b. Man-to-man rating scale. Van Buskirk proposes a simple man-to-man rating scale for evaluating the results of physical education. The assumption is that the pupil is well known by the rater and that in the class there is a normal distribution of ability from poorest to best. A part of the Van Buskirk scale is here shown. Other divisions of the scale relate to neuromuscular control, recreational information, sportsmanship, etc. When this type of scale is used for self-ratings, the pronouns are changed to "you," and questions like "Do you know . . . . ?" etc., are asked.

INDIVIDUAL RATING SCALE FOR EVALUATING THE RESULTS OF PHYSICAL EDUCATION[2]

I. Physical information:	A	B	C	D	E	Score
1. Does he know the factors of normal growth and development?	10	8	6	4	2	
2. Does he know a sufficiently large number of activities?	10	8	6	4	2	
3. Does he know what his strength and energy should be? The physical requirements for different occupations?	10	8	6	4	2	
4. Does he know his shortcomings and deficiencies? How much improvement he can make?	10	8	6	4	2	
5. Does he know physically fit people to emulate?	10	8	6	4	2	
II. Physical habits and attitudes:	**A**	**B**	**C**	**D**	**E**	**Score**
1. Does he have an impulse to keep physically fit and assume responsibility to get fit?	10	8	6	4	2	
2. Does he feel ashamed when found physically unfit?	10	8	6	4	2	
3. Has he formed the habit of taking a normal amount of play?	10	8	6	4	2	
4. Does he constantly measure his physical achievements and know relatively his physical ability?	10	8	6	4	2	
5. Does he constantly analyze his physical shortcomings?	10	8	6	4	2	

c. Point-score system. The point-score system, used rather widely and with conspicuous success in small schools, is illustrated in the chart, "Physical Education Record," which follows. The total score for the year evaluates understanding as revealed through (1) knowledge, (2) participation, and (3) leadership.

The results shown in the record indicate the relative success with which each individual has applied his knowledge in the physical-education activities of school life. For instance, when a student corrects a physical defect after it has been called to his attention (and to the attention of his parents), it is reasonable to suppose that he understood that the defect existed, that it was injurious to his record, and that by correcting it he gained some insight into the method and values of the correction provided. In much the same way, a high rating for participation in sports may be assumed to measure understanding to some extent, as, for example, understanding of rules, training procedures, strategy of play, and sportsmanship. Likewise, points awarded for leadership reflect some understanding of such activities, just as grades awarded for scholarship reflect, however grossly, some amount of understanding.

[2] Adapted from L. Van Buskirk, "Measuring the Results of Physical Education," *Journal of Educational Method,* VII (February, 1928), 221-29.

PHYSICAL EDUCATION RECORD[3]

	Points
Health and hygiene	200
Leadership	50
Scholastics	200
Spirit and co-operation	50
Athletics or physical-education grades	500
Total	1000

Health and hygiene	20%
Leadership	5%
Scholastic average	20%
Spirit and co-operation	5%
Athletics	50%
	100%

			HEALTH AND HYGIENE			MAJOR SPORTS				MINOR SPORTS				INTRAMURAL SPORTS											LEADERSHIP								
NAMES	AGE	CLASS	Physical Examinations	Bonus for Corrections	Theoretical Hygiene Knowl'ge	Football	Basketball	Baseball	Track	Cross Country	Hockey	Swimming	Tennis	Football	Fall Track	Basketball	Boxing	Outdoor Club	Physical Eff. Tests	Baseball	Spring Track	Soccer	Swimming		Athletic	Class	Social	School Council	Spirit and Co-op.	1st Sem. Average	2nd Sem. Average	TOTAL POINTS	RANK IN SCHOOL

Note:—The highest 10% in point score will be eligible for election into Sigma Delta Psi, (National Honorary Physical Education Society)

1. Health and hygiene .... 200 points
   - The physical examination on a 100% basis ...... 100 points
   - Health study or lectures requiring examination .. 100 points
2. Leadership .... 50 points
   - Any worth-while example of leadership may be rewarded.
   - Team captaincy .... 25 points
   - Managership .... 15 points
   - Student or school council .... 10 points
   - Class officer .... 5 points
   - Social or business .... 5 points
3. Scholastics (Maximum, 100 points per semester) .... 200 points
4. Spirit and co-operation (by vote of faculty) .... 50 points
5. Athletics .... 500 points
   - Major sports: letter, 150; 2nd team, 100; participation 50
   - Minor sports: letter, 75; 2nd team, 50; participation 25
   - Intramural sports: championship, 50; participation 20

d. A self-rating scale. A self-rating scale on recreational sports is a method of evaluating the success which a student feels he has achieved from experience in participation, reading, and discussion, all leading to some degree of understanding. For instance, in skiing the student learns the meaning of many terms, such as slalom, snowplow,

[3] Improvised by the committee contributing this chapter.

telemark, cristy, gelandesprung, as well as an understanding of skills and practices related to skiing, such as the different methods of waxing skiis, the advantages and disadvantages of various turns, types of shoes and bindings, the proper length for skiis and poles, types of clothing, hazards, dangers—in other words, a host of ideas which, all together, make for understanding of the sport. The same is true for any sport.

Admittedly, the self-rating scale is not an accurate measuring device, but it provides a quicker and easier means of evaluation than does any type of examination, when only a rough appraisal is needed with large numbers of persons. Provided that a wholesome rapport has been established between instructor and students, the student with much understanding will rate himself relatively high, and the student with little or no experience, relatively low. The records then become especially valuable for guidance, particularly when they are made the basis for personal interviews and group discussion. A suggested form for the self-rating scale relating to recreational sports is here shown.

Self-Rating Scale for Experience and Understanding in Recreational Sports
(Encircle Appropriate Number)

Activities	None	Almost None	Some	Much	Very Much	Points
1. Swimming	1	2	3	4	5	
2. Diving	1	2	3	4	5	
3. Canoeing, boating, and sailing	1	2	3	4	5	
4. Gymnastics (circus) stunts	1	2	3	4	5	
5. Tumbling	1	2	3	4	5	
6. Apparatus (gymnastic)	1	2	3	4	5	
7. Hiking	1	2	3	4	5	
8. Camping out	1	2	3	4	5	
9. Skating	1	2	3	4	5	
10. Skiing	1	2	3	4	5	
11. Sledding or tobogganing	1	2	3	4	5	
12. Dancing (social)	1	2	3	4	5	
13. Bowling	1	2	3	4	5	
14. Golf	1	2	3	4	5	
15. Tennis	1	2	3	4	5	
16. Hunting and shooting	1	2	3	4	5	
17. Fishing	1	2	3	4	5	
18. Cycling	1	2	3	4	5	
19. Climbing mountains	1	2	3	4	5	
20. Team games	1	2	3	4	5	

Total Points________________
Percentile Rating________________

Controlled Observation and Ratings

a. Blanchard Frequency Rating Scale. Blanchard (1) advocates a frequency rating scale for measuring character and personality in

physical-education classes. The scale covers leadership, positive active qualities, positive mental qualities, self-control, co-operation, social action standards, ethical social qualities, qualities of efficiency and sociability. Each of these nine units is covered by means of from two to four positive statements about the behavior to be observed and rated. The control is in frequency of observation, and the rating is done according to defined standards. The unit on leadership alone is as follows:

FREQUENCY RATING SCALE

Name ____ School ____ Grade ____ Age ____ Name of Rater ____ Date ____	No Opportunity to Observe	FREQUENCY OF OBSERVATION					
		Never	Seldom	Fairly Often	Frequently	Extremely Often	Score
Leadership:							
1. He is popular with classmates.......		1	2	3	4	5	
2. He seeks responsibility in the class..		1	2	3	4	5	
3. He shows intellectual leadership.....		1	2	3	4	5	

The score is summed at the right for all items rated. A maximum score of 120 can be obtained. The reliability is .711 and the validity .930, the latter by correlation of one trait action with the rest of the items in its category. The whole scale contains twenty-four trait actions. The ratings are made by the teacher who uses standardized forms. If we can assume that desirable behavior reflects understanding, then the scale may be assumed to measure understanding.

b. Self-rating of physical fitness according to definite standards. Another type of device which is designed to evaluate the understanding which adults have of their own physical fitness is a self-rating form based on definite standards. An example of this kind of form is presented here. An adequate self-rating according to the standards on this blank certainly involves some understanding. The person who knows the meaning of the physical-fitness standards can rate himself, provided he has had experience with the procedure employed in such measurement. The extent of his understanding would be revealed, in part, by the number of items on which he was able to rate himself reliably. On the other hand, the person who does not understand the standards or the means to be employed in securing the needed measures would be able to rate himself on but a few items. This type of instru-

ment is again best suited to the making of rough appraisals and tentative surveys, especially when large numbers of persons are involved.

SELF-RATING OF PHYSICAL FITNESS ACCORDING TO DEFINITE STANDARDS [4]

Aspects of Fitness	Estimate Your Own Rating on Each Item by Encircling the Right Number						
	Do Not Know	Poor	Fair	Average	Good	Superior	Points
A. PHYSIQUE:							
1. Normal weight—Not more than 10 lbs. over or under average weight for skeletal build and age	0	1	2	3	4	5	
2. Normal adipose tissue—Not more than 1 in. (women) ¾ in. (men) double fold of skin and fat on cheeks, arms, abdomen, waist, buttocks	0	1	2	3	4	5	
3. Normal body type—Not extremely frail (ectomorphic), soft and fat (endomorphic), nor extreme in proportions, and moderately well muscled	0	1	2	3	4	5	
4. Chest expansion—At least 3.0 inches	0	1	2	3	4	5	
5. Vital capacity—At least average for body type	0	1	2	3	4	5	
6. Chest girth (expanded)—Greater than abdominal girth (normal) by at least 5 inches	0	1	2	3	4	5	
7. Muscles: Biceps, abdominals, glutei, thighs, calves—Hard and well developed under voluntary contractions	0	1	2	3	4	5	
8. Posture—Normal head, chest, spine, abdomen, feet	0	1	2	3	4	5	
B. ORGANIC EFFICIENCY:							
9. Neuromuscular steadiness—Hold full glass of water steady 30 sec. at arm's length	0	1	2	3	4	5	
10. Recovery from dizziness—Walk 10 ft. on line, 5 sec. after 10 turns around finger on spot	0	1	2	3	4	5	
11. Breath holding—60 sec. after three deep breaths	0	1	2	3	4	5	
12. Breath holding after exercise—30 sec. after 60 sec. run in place	0	1	2	3	4	5	
13. Pulse ratio—Score 2.5 after 30 step/min. exercise	0	1	2	3	4	5	
14. Schneider Index—Score in the 12-18 range	0	1	2	3	4	5	
15. Medical history and inspection—Satisfactory rating	0	1	2	3	4	5	
C. MOTOR FITNESS:							
16. Ability to swim—440 yds., any combination of strokes	0	1	2	3	4	5	
17. Motor fitness screen test: Men's test—at least 50% efficient. Women's test—at least 50% efficient	0	1	2	3	4	5	
18. Pick-up and carry partner—At least equal of own weight, 100 yards	0	1	2	3	4	5	
19. Mile Walk and Run—10 min. (or 1000 hops, varied)	0	1	2	3	4	5	
20. Agility Exercise—10 times within 60 sec	0	1	2	3	4	5	

WHAT IS YOUR SCORE?

Poor (Below 60)	Fair (60-69)	Average (70-79)	Good (80-89)	Superior (90-100)	Date:______	Total Points______
☐	☐	☐	☐	☐		Per Cent Score______

As was explained in connection with device (*a*) above, follow-up questioning is especially valuable for increasing sureness of evaluation as a basis for sectioning, for guidance, and for further instruction. Not the least of the values of this device is its usefulness for purposes of

[4] Devised and used at the McKinley Y.M.C.A., Champaign, Illinois.

motivation. Many persons, after rating themselves for physical fitness, have become interested in learning more about physical fitness, the standards employed for evaluating it, and the appropriate procedure in taking corrective work.

c. Check sheet for form. Another type of device is the check sheet for form, used by coaches, teachers, or squad leaders, to rate performance of a player. The sample here given relates to softball, but obviously similar check sheets can be prepared to evaluate form in other sports.

SAMPLE CHECK SHEET FOR SOFTBALL BATTING FORM [5]

Date	Rater's Initials	
________	____________	Player's name________________________
		Captain's name________________________

Instructions: Rate the player each time he bats. Place a tally mark in the space which precedes the best description of player's form in each of six categories. Indicate your observation of errors in the right-hand half of the page, again with a tally mark. Write in any additional errors and add comments below.

	Errors
1. *Grip*	
________good	________Hands too far apart
________fair	________Wrong hand on top
________poor	________Hands too far from end of bat
2. *Preliminary stance*	
________good	________Stands too near plate
________fair	________Stands too far away
________poor	________Rear foot closer to plate than forward foot
	________Stands too far forward
	________Stands too far backward
	________Bat not in readiness position
3. *Stride or footwork*	
________good	________Fails to step forward
________fair	________Fails to transfer weight
________poor	________Lifts back foot from ground
4. *Pivot or body twist*	
________good	________Fails to twist body
________fair	________Fails to wind up
________poor	________Has less than 90° of pivot
5. *Arm movement or swing*	
________good	________Arms held too close to body
________fair	________Rear elbow held too far up
________poor	________Bat not held parallel to ground

[5] M. Gladys Scott and Esther French, *Better Teaching through Testing,* p. 168. New York: A. S. Barnes & Co., 1945.

6. *General* (Eyes on ball, judgment of pitcher, etc.)

________good	________Jerky action
________fair	________Tries too hard
________poor	________Poor selection of bat
	________Lacks confidence

When used by one player to judge another, the form check sheet evaluates the rater as well as the one rated. The ability of the rater (including his understanding of good form) is revealed by the speed and correctness with which he makes the entries. An experienced coach can watch a batter, then check his performance on the rating sheet at once with considerable accuracy. A novice, who has little understanding of good form, cannot rate batters in this way. Hence, if the novice's ratings are compared with those of an expert, a good measure of the understanding of the inexperienced rater is afforded. Of course, the player being rated is also appraised with respect to his understanding of good form. No separation is obtained between his knowledge of good form and his motor ability to demonstrate it, except in the case of a relatively few persons of good mental ability who lack motor co-ordination, and except, in the case of others, during early stages of learning. Once the ideal of good form is known, practice under good coaching builds the co-ordinated and integrated motor action which results in performance at the level of understanding.

Standardized Written Tests of Knowledge

Standardized knowledge tests have appeared in the literature of physical education since 1929. The aspects covered in available printed form are: badminton, baseball, basketball, field hockey, first aid, golf, life-saving, sports interest, soccer, source materials, swimming, syphilis and gonorrhea, tennis, and physical training.

Rodgers and Heath (**12**) were among the first to develop acceptable knowledge tests in team-game activities. Other acceptable tests have been devised by French (**3**), Hemphill (**5**), Hewitt (**6**), Murphy (**10**), Scott (**13**), and Snell (**15**). A study of these tests shows that they adhere to approved types of form [6] as used for academic knowledge tests and that they have been developed with adequate regard for

[6] G. M. Ruch, *The Objective or New-Type Examination.* Chicago: Scott, Foresman & Co., 1929; H. E. Hawkes, E. F. Lindquist, and C. R. Mann, *Construction and Use of Achievement Examinations.* Boston: Houghton Mifflin Co., 1936; J. M. Lee and P. M. Symonds, "New Types of Objective Tests: Summary of Recent Investigations," *Journal of Educational Psychology,* XXIV (January, 1933), 21-28.

validity and reliability. In general the content is proportioned somewhat as follows:

1. Historical development of activity........................10 questions
2. Analysis of form (technique, mechanics)..................10 questions
3. Analysis of strategy in game situations...................10 questions
4. Rules of play, fouls.......................................10 questions
5. How to avoid fouls...10 questions
6. Area, spacing, dimensions (diagrams)....................10 questions
7. Equipment and supplies....................................10 questions
8. Safety precautions ....10 questions
9. Conditioning ....10 questions
10. Terminology ....10 questions

Almost all of the tests are validated by the "expert jury" method, although there are examples of correlations with the amount of space devoted to given topics in textbooks. Correlations of the scores on the knowledge tests with performance in the activity have been very low as a rule. Reliability is usually checked by the re-test self-correlation method or by the split-halves method, with the Spearman-Brown prophecy formula correction. Almost all of the better tests are of the true-false or multiple-choice type, but some are of the combination "battery" type. The preference is overwhelmingly for quick-scoring tests which permit use of a matching key. The essay-type question is practically never used because of the time required to read the answers of large numbers of pupils.

It would seem to be desirable to separate tests and test items which measure understanding in the ideal sense (an advanced level of comprehension of basic principles) from those which measure merely the ability to recall memorized facts. The differences between the two extreme types of mental process, and hence between the two types of test item, are recognized by the authors of this chapter, but the differences are those of degree. Moreover, there is no very satisfactory way to separate memory items from understanding items, save perhaps through the use of questions of increasing difficulty and complexity (see chap. iv).

In standardized and locally prepared written tests some plan of progressive difficulty should be worked out in physical education as has been worked out in the Wood-Lerrigo Health Behavior Scales. At least, we should think of questions as testing different levels of understanding, such as:

Low level ....Memory of easy rules and simple plays
(preschool, elementary school) and health rules

Intermediate level (high school, general adult population)	Memory of more complicated rules and plays; some reasoning in applying rules to hard plays; elementary hygiene and fitness
High level (college teams; professional-training level)	Fundamental reasons for rules, plays, training procedures, body mechanics; mechanics and kinesiology of skill; physiology of exercise; advanced hygiene

Tests Suitable for Classes in High School and College

a. *Multiple-choice type questions*

Baseball.[7] Check the correct response.

In order to secure the greatest velocity for a pitched ball across the plate, the pitcher must throw:

________ (1) An outcurve
________ (2) A drop
________ (3) A straight ball
________ (4) An in-shoot
________ (5) A fade-away

For experienced players this question may seem to require only the recall of a fact, but for novices it sets up a mental struggle to decide which response is correct. Thus, we cannot be sure when the answer measures simple memory and when it measures a deeper understanding. This is one of the outstanding faults of multiple-choice (and of other so-called "objective" test) forms.

The surest way to obtain a real appraisal of understanding is to require a response which elaborates the basic principles in terms of fundamental reasons (physical, physiological, or psychological). Sometimes essay questions will serve this end, as, for example, if the question just above were stated to read:

Explain in a one-page statement why the fastest curved ball does not usually travel over the plate as fast as does the fastest possible straight ball.

The following type answer shows insight into basic principles and a high level of understanding, rather than the recall of previously memorized facts.

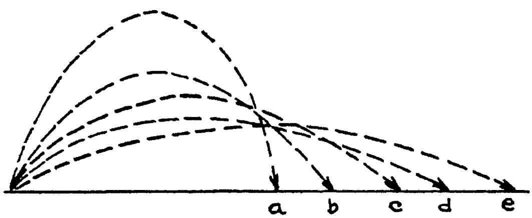
For a given amount of spin on the ball, the ball will not "break" if the speed is too great; also, a spin ball of the "break" type cannot be thrown as fast as a straight ball, because of the compound snap and rotation required in the arm acting as a third-class lever. A faster ball is obtained when

[7] This sample is chosen from Irene Palmer, "Tests of Knowledge," *Tests and Measurements*, pp. 95-103. New York: A. S. Barnes & Co., 1932.

all the available arm force acts to propel the ball rather than to rotate it. To make the ball "break," its spin must be fast enough to create a difference in frictional resistance so that the air pressure builds up on one side of the ball (that revolving forward to create head-on friction with the static air) and diminishes on the other side of the ball (that revolving away from the head-on friction). When the spin is fast enough in proportion to the head-on friction, the ball "breaks."

Golf.[8] Check the proper letter to indicate the answer which is relatively most correct.

Of the flights shown in the diagram, which most closely approximates that of the mid-iron? (Consider all as iron shots.)



a. ________________

b. ________________

c. ________________

d. ________________

e. ________________

b. True-false type questions

Basketball. Mark the statement (+) if it is true, but mark it (−) if untrue.

_______ 1. During a pivot one foot should be in contact with the floor until the ball is passed.

_______ 2. Tall men should stay away from the backboard on the free-throw lane when a free throw is being taken.

Football. Mark the statement *T* if it is true and *F* if it is false.

_______ 1. Ball carriers should keep the ball on the side opposite any would-be tackler.

_______ 2. The defensive full-back should wait for the advancing ball-carrier.

Tests Suitable for Professional Courses in Physical Education

In the professional courses in physical education written examinations of considerable complexity are used. There are many such technical courses, but the examinations used can be exemplified in only a few areas in the space allotted. Among the examinations which have been published, those for basketball officials[9] may be cited. Esther

[8] M. Gladys Scott and Esther French, *Better Teaching through Testing,* pp. 179-209. New York: A. S. Barnes & Co., 1945.

[9] Women's National Officials Rating Committee of the Women's Athletic Section, American Association for Health, Physical Education, and Recreation.

French [10] has made an extensive study of typical professional examinations. The questions in these examinations deal with knowledge and, as compared with nonprofessional tests, are much more penetrating in their intention to search out the reasons behind knowledge about the mechanics of skills, physiology of exercise, and related technical subject matter. Most professional examinations do not, however, require a sufficiently high level of understanding in terms of basic scientific principles.

a. Laboratory measurement procedure

The following questions have been taken from a course in tests and measurements.[11]

The understanding of a specialized laboratory procedure may be illustrated by the following question:

(1) Trace and measure a typical heartogram and insert in the accompanying tabulation form the raw scores, the standard scores, the corresponding percentile scores, and the composite and average standard scores (use text and any available tables):

	Raw Scores	Standard Scores	Percentile Scores
1. Area under the curve in a single cycle..			
2. Systolic amplitude			
3. Dicrotic amplitude			
4. Fatigue ratio			
5. Work to rest ratio....................			
6. Single cycle time.....................			
7. Rate per minute......................			
8. Obliquity angle			

Composite Standard Score____________

Average Standard Score____________

(2) Write a paragraph interpreting the meaning of the results.

b. Use of profile chart

How to rate one's self on a standard profile chart is an important type of understanding. It is illustrated by the following question:

[10] Esther French, "The Construction of Knowledge Tests in Selected Professional Courses in Physical Education," *Research Quarterly,* XIV (December, 1943), 406-24.

[11] From *Physical Education,* 73. Urbana, Illinois: University of Illinois.

Using your own raw scores on a variety of physical-fitness and achievement tests, obtain the corresponding standard scores from the standard-score tables in the physical-fitness workbook [12] and plot these on the standard-profile sheet furnished. Plot at least three scores of each of the following types:

1. Physique
2. Organic efficiency
3. Motor performance.

c. Determination of improvement

How to determine improvement by means of standard-score tables is an important technique illustrated by the following question:

Compare your initial and final performances to determine the standard score per cent improvement, using the tables and raw data in your own fitness workbook (2) for any five items.

Items	Initial Raw Data	Initial Standard Scores	Final Raw Data	Final Standard Score	Per Cent Improvement

d. Theme-type question

The understanding that one has of his own physical fitness can be evaluated by his ability to summarize his status in a one-page statement:

Write one page summarizing your own physical fitness under the following heads:

Physique
Motor fitness
Organic efficiency
Outstanding needs
Prescription of activities

Include any objective scores on physical fitness tests taken within the last year. (Use of personal workbook is permitted.)

e. Analytical diagrams

1. Draw the vectoral diagram which illustrates the physical forces which make a baseball curve.

[12] Refers to the *Physical Fitness Workbook* used in the basic physical-fitness classes at the University of Illinois (2).

2. Draw the analytical diagram which illustrates why the up-kick is more effective for forward propulsion than the down-kick in the swimming flutter kick.[13]
3. Draw the projection diagram of a running broad jump and label properly to show how the physical law of projection applies to the event.[14]

Performance Tests

Physical-education tests in use are principally performance tests. These fit in naturally with the fundamental task of providing suitable *physical activity.* Many of these tests involve understanding to a considerable extent in order to make a good score. For instance, how could anyone make a good showing in pole vaulting without understanding how to vault? The performance reflects both understanding and physical capacity, though the two aspects are not separated. Such performance tests are very numerous in the literature of physical education, and good textbooks which describe them in full are readily available.

Summary and Recommendations

It is clear that opportunities abound for the measurement of understanding in physical education. Examples of such measurement are cited in this chapter which exemplify:

1. Simple observations and ratings
2. Controlled observations and ratings
3. Written tests
4. Performance tests

Since 1929 the use of formalized procedures for measuring understanding in physical education has greatly increased. Under pressure of time and inadequate leadership the formal measurement of understanding by means of written tests usually disappears; with still greater lack of time and leadership, even the performance tests disappear. The typical teacher then depends upon spontaneous group comments or man-to-man comparisons or conferences, both to develop and to measure understanding. Physical-education teachers value the worth of their methods to engender understanding in about the order stated above. Many are inadequately trained in the tests and measurements already published in their own field. Even more have little scientific foundation for testing scientific knowledge of particular skills, and

[13] T. K. Cureton, "Mechanics and Kinesiology of the Crawl Flutter Kick," *Research Quarterly,* I (December, 1930), 87-121.

[14] T. K. Cureton, "Mechanics of the Broad Jump," *Scholastic Coach,* IV (1935), 8-9.

many of them lack the physical capacity and fitness needed for skilful performance.

There needs to be a continuous research effort to graduate the difficulty level of devices to evaluate measurement in this field. At the present time there is little to distinguish tests used at the elementary-school level from high-school tests, or high-school tests from those used at the college level or in teacher-training classes. Continuous critical appraisal needs to be made of the tests and of the results. New tests need to be created which will parallel the practical work in sports and physical fitness now being done in physical education. This program points toward a better integration of health education and physical education.

The fundamental problem in developing a society rich in the outcomes of physical-education activities is the problem of securing understanding. Unless each individual appreciates the meaning of physical-education activities, he lacks the ability to direct his life, the life of the young, and the life of society into channels which will realize a maximum of desirable outcomes associated with relatively full participation over the whole span of life. The school must accept the development of understanding as a responsibility. Such acceptance on the part of the instructor in physical education necessitates a definite statement of objectives in terms of understanding and the development of techniques for the evaluation of this understanding. Without these, intelligent progress is impossible. For some time theorists in this field have stressed understanding (**16**, **18**, **19**). More recently, attempts to measure some of the understandings have been accelerated (**13**, **15**). However, there is much more work to be done before an adequate graduated program can be presented.

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CHAPTER XIII
THE MEASUREMENT OF UNDERSTANDING IN HOME ECONOMICS

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The first part of this chapter consists of an organized statement of those outcomes in education for personal and family living which appear to deal primarily with the acquisition of understandings. In the second part are presented illustrative devices for measuring some of the understandings. In the absence of any official or universally accepted statement of the outcomes of home-economics education, a tentative list was compiled by this committee after surveying the recent literature in home economics and in general education.[1] These outcomes were then submitted to a group of collaborators[2] from

[1] See bibliography at end of chapter.

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public schools, teachers colleges, and universities who made additions, deletions, and revisions.

In harmony with the purposes of the yearbook, many of the outcomes which involve the development of skills, attitudes, appreciations, and information in the field of home economics have been omitted for this somewhat "official" test. Only those which clearly emphasize understandings have been retained.

The list of outcomes which was finally selected, and which is presented below, is also in general agreement with the results of a study recently made by a joint committee [3] of the American Home Economics Association and the American Council on Education.

Outcomes of Education for Personal and Family Life

The outcomes of personal and family-life education have been organized within seven general areas: *personal adjustment, use of time and energy, use of money, the family and children, foods and nutrition, clothing and textiles,* and *the home.*

I. *Outcomes relating to personal adjustment*
   A. Health. The pupil should understand:
      1. His own mental and physical health status, especially in regard to food habits; rest, sleep and personal hygiene; adequacy of of vision, hearing, and other senses; recreational practices; emotional adjustments.
      2. The importance of seeking help and information for improved health.
      3. The relationships of safety and health to personal, family, and and community betterment.
      4. First-aid procedures and methods of caring for those who are ill.

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[3] Clara M. Brown (chairman), University of Minnesota; Sarah Gibson Blanding, Dean of the College of Home Economics, Cornell University; Hester Chadderdon, Iowa State College; Flora M. Thurston, Cornell University; and Ben D. Wood, Columbia University.

5. The need for and means of controlling communicable diseases and preventable accidents.

B. Other personal adjustments. The pupil should understand:
1. Means of achieving an attractive personal appearance.
2. Ways of behaving in a socially acceptable manner.
3. Ways of working well with people.
4. The desirability of sharing the use of and responsibility for family possessions.
5. The importance of a desirable degree of independence from parental ties, coupled with a friendly relationship with parents.
6. The importance of a wholesome attitude toward sex.
7. Ways of making friends successfully with both sexes.

C. Vocational choice. The pupil should understand:
1. The demands of vocations relating to homemaking in terms of personal qualities, abilities, and specialized training.
2. Procedures to follow in getting a job.
3. The values to be weighed and the decisions to be made regarding a payroll job versus homemaking for women or a combination of the two.

II. *Use of time and energy*. The pupil should understand:
1. Methods of deciding what needs to be done in a given situation, taking into account personal energy and skills.
2. Ways to compare conflicting values and to make choices in light of personal and family needs.
3. Principles relating to the management of resources.
4. Ways of substituting skill for money in maintaining standards of living.
5. Procedures in planning with others a satisfactory division of labor at school and in the home.

III. *Use of money*. The pupil should understand:
1. Ways of anticipating probable expenditures and making short-time and long-time plans for spending.
2. Methods of using money to buy goods and services with optimum satisfaction.
3. The value of joint financial planning and records of expenditures.
4. Banking procedures and the use of credit.
5. Distribution of income in the United States and factors that affect its stability.
6. Effects of social and commercial pressures on purchasing habits, and governmental attempts to protect consumers.
7. The importance of insurance, annuities, social security, and savings for financial security.
8. Relationships of personal and family welfare to the economy of the nation and the world.

IV. *The family and children*

A. The family. The pupil should understand:

1. Factors which contribute to courtship and successful marriage.
2. Biological aspects of marriage.
3. The importance of counseling services and legal requirements for marriage.
4. Kinds of crises likely to occur in families and how they may be met.
5. The adjustments which need to be made among family members of different ages.
6. The importance of aesthetic and cultural values in the home.
7. Means of fostering and building wise family traditions, ideals, and spiritual values.
8. The variety of racial, national, religious, and family patterns in the United States, with acceptance of their implications.
9. Ways to help make the family situation democratic.

B. The children. The pupil should understand:

1. Reasons for children behaving as they do.
2. The constituents of normal physical, mental, social, and emotional development.
3. The significance of bearing and rearing children for the family and for society.
4. The importance of guiding children's play intelligently and of making and selecting play materials wisely.
5. The influence of the child's environment on his security and development.

V. *Foods and nutrition.* The pupil should understand:

1. Ways to order food in a public eating place to meet nutritional standards at a reasonable price.
2. The importance of acceptable table manners.
3. Principles of food preservation.
4. Factors entering into the planning of meals for individuals and families.
5. Cookery principles and ability to use them.
6. Methods of serving food attractively.
7. Methods of preparing and serving food for people who are ill.
8. Purpose and effects of governmental regulations (enrichment, labeling, protection against spoilage, and adulteration).
9. Basic principles of child nutrition and feeding.

VI. *Clothing and textiles.* The pupil should understand:

1. Methods of choosing harmonious and becoming textures, colors, and styles.

2. Principles governing the selection of clothing and household fabrics that are suitable for the desired purpose at a reasonable price.
3. Ways of constructing, repairing, and making alterations in clothing and household furnishings.
4. Principles of laundering clothes and household fabrics.
5. Methods of using a sewing machine and of keeping it in running order.

VII. *The home.* The pupil should understand:

1. The relation of housing to social problems and the need for group planning for housing.
2. Factors which an individual or a family must consider in the selection of living quarters.
3. Principles involved in the arrangement of furniture and furnishings for comfort, convenience, and attractiveness.
4. Care of furnishings and equipment.
5. Principles involved in the planning of home grounds to make them attractive and to insure privacy.

Illustrative Techniques for Measuring Understandings

To measure the extent and quality of the understandings listed above, one would need to employ a large variety of devices and techniques. Moreover, the degree to which learners may be expected to achieve understandings varies with age, sex, past experience, intellectual ability, purpose, and the extent and quality of the instruction they have received. It may never be possible to obtain objective evidence respecting achievement of some of the understandings sought in school, but this fact does not justify the restriction of evaluation to the measurement of information alone, valuable as this is.

The types of evaluation techniques described and illustrated have been grouped under three headings: *Analysis of records, reports, and creative work; Observing and recording behavior;* and *Testing understanding and judgment.* Just before each illustrative device the outcomes which may be involved are indicated by Roman numerals, letters, and Arabic numbers which refer to the outcomes as listed on pages 254-57.

Analysis of Records, Reports, and Creative Work

Student reports and other types of informal records and reports which students are asked to prepare and keep (such as diaries of activities, descriptions of summer experiences, notes on projects carried on in the home or in the community, explanations of hobbies)

may be analyzed to discover the degree of understanding which each learner has achieved. Particularly will these student reports be helpful when they are planned with the idea of getting evidence of understanding from them.

(Objective I-B-3). An illustration of successful co-operative enterprise is provided by a report written by students of East High School, Denver, Colorado, in which they describe their core classes (**9**: 295-309). The core program of this high school was initiated in January, 1938, the six teachers in charge of the experiment planning each course in co-operation with the pupils. At the end of the year the pupils wrote an evaluative report of their progress under the new plan of instruction.

Notebooks containing records of information may give evidence of the student's understanding. For example, they may indicate understanding of the steps to be taken to reach a desired goal, such as plans for operating a school lunch for underweight third-grade pupils, or a party for preschool children. However, notebooks that merely record what was said in class or what was copied from reading references are likely to have little or no value in furnishing evidence of understanding.

Questionnaires, opinionnaires, check lists, and self-inventories of various kinds may be useful in revealing understanding if the proper *rapport* is established with the students. When students are sure that the information revealed will be used to help them rather than to serve merely as a basis for grading, their responses can usually be accepted. Sometimes, too, the information desired may be more readily secured by asking students not to sign their names.

Records of physical examinations, which commonly show health and developmental status, suggest remedial treatment needed, and eventually describe any improvement that may have been made, may also be designed so as to reveal certain understandings on the part of pupils.

Library records of voluntary reading reveal both breadth and depth of reading interests, and when accompanied by written responses or supplemented by oral questioning, may be very illuminating with respect to level of understanding attained.

Cumulative records on file in the office of the principal, counselor, college dean, or registrar are valuable not alone for educational and vocational guidance and for personal counseling. In addition to information on scholastic standing and ability, these records may well include such information as: health history, participation in school

activities, types of work experience, employers' ratings, and interviews with parents. If such data are accompanied with the *reasons* for decisions and if the bases for the judgments are made clear, an enormous amount of evidence concerning the development of understanding in pupils can be gleaned from them.

Incidentally, an analysis of such records can be very informing with respect to the understandings which a prospective teacher has or has not acquired. That this is true is shown in the following analysis of library and office records[4] made by a student teacher. Her statement shows how she increased her own understanding of certain personality traits and interests of one of her pupils and thus improved her ability to work with this child.

An Analysis of School Records

Cumulative records on file at the school show that Blanche, an eighth-grade pupil, has been quiet and very reserved all through school. She likes to read but does not draw out as many books from the school libary as do the other girls in this group. However, she is reported to be superior in her school work in general. The books that she has borrowed from the school library indicate a variety of interests. Some of these, such as *Soldier-Doctor,* which is a biography of Gorgas, and *Captains Courageous,* suggest an interest in action. The choice of another book, Dickens' *Stories about Children,* may indicate Blanche's rather passive personality. Last year she read the *Second Jungle Book, Christmas,* and *Christina of Old New York,* the choice of which seems to denote interests of similar character in each case. In the sixth grade she was a fluent oral reader but read too fast and with little expression. Her conversations in the classroom or outside show little expressiveness or excitement. However, Blanche has good work habits. She is prompt, is not inhibited, and is successful as a student. She is a logical thinker, but must be urged to participate. She is very tolerant, but easily influenced by others. Her home conditions are excellent in every way.

Reports of other teachers were compared with my own observations. However, of all these records, the library report more than any other increased my understanding of Blanche's personality. The reports from the cumulative records served to strengthen my own observations.

Comment upon plays, fiction, movies, biographies or case histories of families represent another source of evidence of understanding and judgment.

Creative productions such as original stories, radio skits, new dishes, dress designs, scrap books, and cartoons may all have value in furnishing evidence of certain understandings.

[4] Contributed by Dorothea Jacobs, a member of the Junior class at the Buffalo State Teachers College, Buffalo, New York.

Observing and Recording Behavior

The home-economics teacher continually has opportunities to learn how students think and feel in the day-by-day laboratory work carried on in an atmosphere of informality, in the sessions held after class to work on some school project, and in the home-management house when people run in to tell her good or bad news.

As the teacher watches students working on exhibits and displays, in dramatic productions, or during social functions, intelligent observation will discover evidences of understanding, judgment, and the ability to solve problems, as well as clues to behavior which might otherwise not be understood. Sometimes it is enough merely to note what is happening. Often it is desirable to develop forms for recording specific behavior in the laboratory, on field trips, in the nursery school, or on the playground.

Anecdotal records of student behavior and histories of problem cases may have value when records are desirable. These may be made incidentally, or they may be systematized.

(Objectives I-B-2 and VI-2). The following excerpt from an anecdotal record exemplifies a systematic way of recording and evaluating anecdotes in terms of specific objectives (**11**: 73-75).

The interpretation of these recordings may reveal understandings if the goals which are being evaluated provide for the development of understanding.

An Anecdotal Record

In measuring progress toward a goal, an anecdotal procedure may be used. The keynote to success in using this type of device lies in the brevity and objectiveness of the record itself.

Progress Record

Objective: To learn how to select clothes and accessories
(X) indicates typical
(O) indicates unusual

Date and Place of Observation	*Comments*	
April Church (Easter Sunday)	The tailored copenhagen-blue suit and harmonizing felt hat looked well-chosen for the occasion. Her shoes were neat and of good style. Her navy purse was suitable for other outfits also.	O
June 6 School Party (informal)	Mary chose a floor length formal because she did not think her suit appropriate for the occasion. She was the only girl wearing a formal.	X

This sort of anecdotal record may extend over a period of several months instead of being ended when the unit to which it refers is finished. In this way, the device would check on whether or not the girls were maintaining the standards set up during the unit. Such a record would be handed in at the end of the school year or whenever the group wished.

A profile of an individual student may be made by checking a number of incidents recorded previously in anecdotal form on a device similar to the one here shown. The points where checks have been entered may then be connected to form a "verbal snapshot" of the student. Recordings may be made by a friend, by the student herself, or by the teacher. Included among the items in such a profile at least some would ordinarily be concerned with the pupil's understanding.

EVIDENCE OF RESPONSIBLE PARTICIPATION IN SOCIALLY SIGNIFICANT ACTIVITIES[5]

BEHAVIOR	EVIDENCE		
	Weak	Average	Strong
Attends meetings			
Prompt at meetings.....................			
Makes suggestions			
Shows interest			
Volunteers work			
Obeys club rules.......................			
Co-operates with other members.........			
Follower as well as a leader...........			
Cheerful			
Suggests worth-while projects..........			

(Objectives I-B-2 and 3). The accompanying illustration of a profile based on a portion of a form devised for use in the interpretation of anecdotal records indicates the types of behavior which reflect pupil understanding of a particular social concept.

Check lists, rating scales, and *score cards* offer means for recording the observer's judgment and represent devices which are finding wide use in the field of home economics. These, too, when so planned will contain evidence of pupil understanding.

(Objectives I-B, IV-A and B). The charts of "Developmental Sequence in Learning" in *Family Living and Our Schools* (**10**: 419-36)

[5] Adapted by Evelyn M. Herrington and Maurice E. Troyer, University of Syracuse, Syracuse, New York.

may well form the basis for developing a series of check lists or other rating devices.

Other illustrations are: (Objectives II, III, IV) "How Do You Rate as a Home Manager?"[6] and (Objectives I, II, III, IV, V) "A Guide to Evaluation and Improvement for Use in Home-Management Houses."[7]

Below are excerpts from two check lists and a rating scale which, if carefully used, would help reveal students' understandings.

PUPIL'S INDIVIDUAL CHECK LIST FOR INTEREST AND RECOGNITION OF BEAUTY IN EVERYDAY LIFE[8]

(Objective IV-A-6)

	Yes	*Sometimes*	*No*
9. Have you undertaken a yard-improvement project?	_____	_________	_____
10. Do you make the foods that you serve at home as attractive as possible?	_____	_________	_____
11. Does attractiveness of books and magazines influence your choice in selecting them? Give illustrations. ____________	_____	_________	_____
12. Have you noticed anything today because of its beauty? If so, what?____________	_____	_________	_____

CHECK LIST FOR PERSONAL APPEARANCE AND NEATNESS[9]

(Objective I-B-1)

(1) Careless; thoughtless; neglected
(2) Only occasional care given; hurried and poorly planned care
(3) Acceptable; moderate effort given; fair results
(4) Careful; thoughtful attention given; excellent results

1 2 3 4 *Clothing:* Clean; well pressed; appropriate; becoming; fasteners in place; no spots, rips or loose trimming.

1 2 3 4 *Hair:* Clean; glossy; arrangement simple and becoming; appropriate for school.

1 2 3 4 *Hands and fingernails:* Clean; nails shaped to conform to shape of fingers; polish natural; cuticle pushed back.

1 2 3 4 *Complexion:* Clean; fresh; healthy; natural.

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[6] Ruth L. Bonde, *Management in Daily Living*, pp. 247-253. New York: Macmillan Co., 1944.

[7] Paulena Nickell and Jean Dorsey, *Management in Family Living*, pp. 438-44. New York: John Wiley & Sons, 1942.

[8] Contributed by Laura Hadley, Alabama College, Montevallo, Alabama.

[9] Contributed by Edna Martin, Seattle Public Schools, Seattle, Washington.

RATING SCALE FOR SELF-EVALUATION OF HOME PROJECTS [10]

(Objectives I-B-4, III-2, 3)

Name of rater____________________ Class__________

Check this before you start work on your project:

	No	*Fairly So*	*Yes*
I. Was the project well selected?			
1. Was this project actually needed (for the whole family; by me personally; am I sufficiently interested that I will really finish it)?	____	________	____
2. Was the project within my family means?	____	________	____
3. Was this a suitable project for me to do at this time (not too difficult or too easy; done at a good time; practical)?........	____	________	____

Check this when your project is finished:

II. Was the project a success?			
1. Did this project help the whole family (or me personally)?	____	________	____
2. Was I able to carry out the plan for my project?	____	________	____

(Objectives VI-1, 2, 3). McDorman,[11] in connection with a joint investigation by the University of Minnesota and the Minnesota State Department of Education, developed a score card for judging garments which had a coefficient of objectivity of better than .90 when used by trained raters and could be used to score a dress in approximately five minutes after a reasonable amount of practice. The score card is reproduced here to show a few of the items considered.

SCORE CARD FOR JUDGING GARMENTS

Score__________

Name__________ Garment________ School________

	1	2	3	4	5	Score
General Appearance						
1. Cut	Off grain or design not centered or matched			True grain; design well located and matched		1. ____

[10] Contributed by Nell Buck and Evelyn Granada, home-economics teachers in summer school, Alabama College, under the supervision of Laura Hardy.

[11] Developed by Mary McDorman for a joint investigation conducted by the University of Minnesota and the Minnesota State Department of Education.

2. Pressing	Wrinkled, stiff, or over-pressed	Satisfactory	2. ______
Fabric			
3. Color	Intensifies undesirable color of skin, hair, or eyes	Enhances color of skin, hair, or eyes	3. ______
4. Design	Spotty or too realistic	All-over, conventionalized	4. ______
5. Texture	Bulky or flimsy, unsuited to pattern, wearer, or occasion	Suitable for garment and wearer	5. ______
6. Quality	Poor, sleasy, will not wear	Firm, durable for purpose	6. ______
7. Sanitary properties	Will soil easily; will not stand laundering, dry cleaning	Will resist soil, launder, or dry clean	7. ______

(Objectives I-A-1, V-4). An effective technique for determining the adequacy of a person's diet is to have him keep a record of all food eaten for a week and then evaluate the recorded consumption. This may be done easily and with calculations simple enough for even elementary-school children to comprehend, through the use of the *Record of Meals for One Week* (Minneapolis, Minnesota: Burgess Publishing Co., 1945) and the *Hatcher Check List for Food Needs* (same publisher). To the extent that children have free choice in foods, these records would probably reflect understanding. At least, they could serve as a point of departure for determining understanding through interviews.

Testing Understanding and Judgment

Because of space limitations it has seemed unwise to give examples of the types of tests which home-economics teachers now use frequently, such as essay, multiple-choice, completion, and true-false. However, all of these may or may not be developed in such a way as to measure understandings. To make them serve this function it is necessary that they be directed toward applications, the reasons for choices, the bases of judgment. Illustrations of test items which meet these requirements will be found in many chapters of this yearbook. The examples given below represent less frequently used types of performance and paper-and-pencil tests which appear to be particularly well adapted to home economics.

Performance tests.[12] Teachers find performance tests especially useful in laundering, cleaning, first aid, furniture arrangement, food preparation and table setting; but they frequently have difficulty in

[12] The reader is advised to consult chapter xv of this yearbook, "Technical Education," for suggestive performance tests.

evaluating what students do and in getting a measure of their understanding. Rating scales are helpful whenever one attempts to evaluate achievement through performance tests which are planned to discover whether students understand well enough to put into action what they are presumably learning (**12**:164-71). The revised form of the *Minnesota Check List for Food Preparation and Serving* (University of Minnesota Press, 1945) is illustrative of this point. The revision is based upon its use in checking several hundred test meals prepared by high-school students. It is easily used and has proved to be highly discriminating and objective.

A "teacher-made" test in the same field follows. It was planned to check whether the students really understood how to set a table for a specific menu.

TEST ON TABLE SETTING[13]

(Objectives I-B-2, II-3, V-6)

Directions: Set up an individual cover for the following menu:

Baked Ham
Boiled Potatoes Buttered Peas
Tomato and Lettuce Salad
Bread Butter
Apple Pie
Coffee

Explain the use of each dish, glass, and piece of silver for your cover. Explain why forks are placed in the sequence used and whether the pie fork is included in the cover.

(The forks are placed in the sequence appropriate for a meal of the type in which we usually start eating from the main plate and then from the salad plate. The pie fork is not included in the individual cover but is supplied with the dessert itself. More than two forks or two teaspoons on a cover give a cluttered appearance.)

(Objectives II-3, IV-A-6, VII-2). The following questions were planned as a performance test for a small class in related art (**11**: 67).

Objective: To be able to apply certain art principles in the home.
Directions to teacher: Collect a group of various sized pictures, either mounted or unmounted, using the bulletin boards and blackboards, and have each student arrange a grouping of pictures, observing the art principles involved and the rules for hanging pictures.
Directions to pupils will depend upon the physical setup of the room and the pictures available for the test.

[13] Contributed by Betty Grever Morrison, a member of the Senior class at Buffalo State Teachers College, and Ruth Buddenhagen, supervising teacher at Amherst Central School, Snyder, New York.

SELECTION OF COLOR HARMONIES FOR COSTUME AND HOUSE FURNISHINGS [14]

(Objectives I-B-1, II-3, IV-A-6)

Directions: Teachers may cut pieces of art paper of different hues and values in the shape of a semi-circle, punch a hole at the center of the base line, and fasten together with a paper fastener so they may be shifted in order to bring any desired colors next to each other. Then the students may be asked to arrange the papers into combinations which would make pleasing color harmonies for specific purposes, and to explain the reasons for their choices.

Pencil-and-paper tests. It is possible to describe specific situations —sometimes very briefly and sometimes with considerable detail—and then to base questions upon them, in order to check students' abilities to make decisions and to indicate their reasons for them. The following example of a test in canning procedures was supplied by Clara M. Brown.

CANNING PROCEDURES

(Objectives I-A-3, 5; V-3, 5)

Many people have difficulty in canning because they do not know the proper procedures to use. Write "X" in the blanks in the *first column* if the procedure described is correct and write "O" if it is not correct. In the blanks in the *second column* write the letter which corresponds to the best reason for your answer. For example, the open kettle method is satisfactory for making strawberry jam because it contains sugar as a preservative; hence "X" is written in the first blank and "D" is written in the second blank.

Reasons

A. May cause an explosion.
B. Food is nonacid.
C. Food is acid.
D. Food contains preservative.
E. Very high temperature is produced.
F. Large amount of Vitamin C is destroyed.
G. Shape and color are preserved.
H. Product is less attractive than when the other methods are used.

Write "X" or "O"	*Reason*	*Canning Procedures*
X	D	Using the open-kettle method for strawberry jam
X	E	Using the pressure cooker in canning meat
O	A	Canning soup by the oven method
X	G	Canning whole tomatoes for salad by the hot water-bath method
O	B	Canning peas by the hot water-bath method

[14] Devised by Mary McDorman and Amy Jean Holmblade as a test for an investigation made jointly by the University of Minnesota and the Minnesota State Department of Education.

The illustration which follows is of the same type. It was prepared for use at the high-school and college level.

ANALYSIS OF A FAMILY SITUATION [15]

(Objectives I-A-1; I-B-2, 5; II-2, 3; IV-A-2, 4, 7, 9)

Directions: Read the ensuing statement and use it as a basis for answering the questions about the situation in the Jones family.

Mr. Jones, a middle-aged little man with a "pinched expression and a stealthy look," earned under $25.00 a week. His various ailments, including poor teeth and frequent nausea at night, were one of the few ways he had of maintaining his self-respect. Marital relations between him and his wife were strained for fear of having another child to support on such a limited income.

Mrs. Jones, plump, aggressive, somewhat stupid, was the dominant character in the family. She used an ulcer and her bad teeth to maintain her rule. Her favorite subject was an older daughter, Jane, who had died in childhood of a bad heart. Jane had been not only pretty, but very intelligent, and, in Mrs. Jones' opinion, Marilyn, the younger daughter, resembled Jane. Betty, the other daughter, was regarded as "dumb" by her mother.

Betty, aged 19, stayed timidly at home, rarely spoke up, and refused to eat—partly in imitation of her parent's stomach troubles, partly to get attention.

Marilyn, aged 16, was of average intelligence but worked exceedingly hard to get good marks. As a result of her efforts, she developed a heart murmur for which her mother sent her to the city hospital for treatment.

Read each of the following statements carefully and record the number before each statement which gives the best answer:

"1," if the statement is probably a justifiable conclusion from the facts given in the description above;

"2," if the statement is probably *not* a justifiable conclusion from the given facts;

"3," if the statement involves too many unexplained facts to judge whether or not it is justified.

Key	*Item Number*	*Statements*
(3)	1	Mr. Jones was fondest of Betty because she resembled him most closely in personality.
(1)	2	Instead of reacting normally to having his teeth out, Mr. Jones might regard their removal as a serious personal loss.
(1)	3	If Mr. Jones could get a good job in which he felt some security, most of his ailments probably would cease even without medical attention.

[15] Constructed by Hazel Hatcher, and contributed by the Board of Examiners of the Michigan State College, East Lansing, Michigan.

(2)	4	Mrs. Jones would probably be very glad to receive medical attention for her ulcer if the family income permitted.
(1)	5	To Mrs. Jones, Jane and Marilyn were the symbol of what she would have liked to be at their age.
(2)	6	If Betty and Marilyn would get jobs away from home, Mrs. Jones would probably develop into a less domineering woman.
(3)	7	Betty's nervous rejection of food would probably stop if Mr. and Mrs. Jones had better relations with each other.
(3)	8	Betty will probably develop into a woman very similar in character to her mother.
(2)	9	The situation would be helped materially if Betty "took sides" with her father.
(1)	10	Relationships between Betty and Marilyn were relatively poor because of Mrs. Jones' decided preference for Marilyn.
(1)	11	Marilyn's physical condition was probably a natural result of trying to fill Jane's place in her mother's life.
(2)	12	Marilyn's heart condition would probably be cured by rest in bed.

The foregoing examples of paper-and-pencil tests which may be expected to elicit evidence of understanding by requiring the student to indicate the reason for a particular decision will serve as illustrations of convenient classroom methods of presenting familiar problems or concepts in a new setting. The resourceful teacher can readily utilize a variety of such exercises in evaluating the understandings gained by the members of a class in different areas of home-economics education as well as at different stages of progress toward selected objectives.

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CHAPTER XIV

THE MEASUREMENT OF UNDERSTANDING IN AGRICULTURE

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OBJECTIVES

Although the objectives of agricultural education include and reflect the over-all objectives of general education, instructional emphasis is usually placed on training for proficiency in farming. The specific aims of such instruction are indicated in the following excerpt from a recently published monograph.

To train present and prospective farmers for proficiency in farming is the aim of vocational education in agriculture.

The attainment of this aim includes making a beginning and advancing in farming occupations and involves training in the production of agricultural commodities, with its constantly enlarging demand for the use of machinery and mechanical devices; training in the protection of animals and plants against pests and diseases; training in activities involved in the marketing of farm products; and training in the procedures of farm management and agricultural finance. It involves an understanding of the problems growing out of farm production and the exchange of farm products, whether on a local, state, national, or international basis.

The attainment of the aim also includes the significant relationship of the farm to the farm home, as well as responsibility in civic and public welfare and co-operative effort for the common good. It embraces instruction in the interdependence of farming and industries closely related to farm and home, as well as the relationships of farming as a business to other industrial

pursuits. It requires training in leadership and a willingness to follow constructive leadership.[1]

Evidences of Understanding

Understanding is an essential objective of agricultural education. To determine whether this objective of instruction is being achieved, one must know the kind of behavior which reflects understanding.

Briefly and generally stated for the purposes of this chapter, it is assumed that understanding manifests itself in the following kinds of behavior:

1. The attainment of a satisfactory result
2. The choice of practices which produce the best results
3. The use of those practices so that the best results are obtained
4. The explanation of "how" and "why" those practices produce the best results
5. The application of basic facts and principles to situations that are new to the individual.

The first three of the kinds of behavior mentioned are usually taken as indications of understanding. When a satisfactory result or product is attained, or when the proper practices are chosen, or when those practices are used to produce the result, it is inferred that there is an understanding of the relationship between the practices and the results. The inference is justified when the decisions are of the individual's own making and reflect his judgment. A clear explanation of this relationship is, however, more convincing evidence of understanding. It shows the basis for his judgment. Still more acceptable evidence of understanding involves the first four kinds of behavior in situations that are *new* to the individual.

The Production of a Satisfactory Result

An individual who obtains high milk and butterfat production per cow has given an indication that he understands what it takes to produce a satisfactory result. A few other measures are the calving efficiency of the herd and the pounds of feed per pound of butterfat.

Some measures of efficiency in swine production are the number of pigs farrowed per litter, the number of pigs raised to 56 days, weight of litter at 56 days (or some later age), weight per pig at 56 days (or some later age), pounds of feed per pound of pork, and per cent of hogs classifying in top-market grades.

[1] *Educational Objectives in Vocational Agriculture.* U. S. Office of Education, Vocational Division Monograph No. 21. Washington: Government Printing Office, 1940.

Measures in corn production are yield per acre and quality of product in terms of percentage of production classifying in top-market grades. Additional measures of efficient production are recognized, some of which may be stated in financial terms, such as cost of production per bushel of grain in the case of certain crops, or cost per pound in the case of hogs.

Measures of the production of a satisfactory result are often subject to factors about which the individual is unaware but which happen to operate in his favor, as well as to factors which are beyond his immediate control. For example, financial measures are affected by price fluctuations. These are beyond his immediate control. High milk production is conditioned by the genetic makeup of the cow. The individual may, by mere chance, have a cow which has inherited the capacity for high milk production. He could be unaware that this factor was contributing to the good results obtained. The achievement of a satisfactory result may be subject also to decisions made by the teacher or by the boy's father, in which case the outcome might not reflect the boy's own understanding. Because of these factors, measures of production are only limited indicators of understanding. One usually wants to check further into the practices used and how and why those practices were used.

The Choice and Use of Practices That Produce Good Results

As an example of this kind of evidence we might take a situation in which an individual has raised a litter of 14 pigs which weighed 583 pounds at 56 days. This accomplishment in itself implies some degree of understanding of efficient methods of swine production. The choice and use of "approved practices," that is, practices which are known to yield good results, gives further evidence that he understands what must be done to obtain a satisfactory result.

Examples of such practices in swine production are: (1) flush sows before breeding; (2) scrub farrowing pens with boiling water and lye; (3) wash lower parts of sow's body with warm water and soap before placing in farrowing pen; (4) haul sow and pigs to clean-ground pasture when pigs are about two weeks of age; (5) in cold weather use a pig brooder after farrowing.

It should be remembered, however, that the choice and use of the practices noted in any given case may be the result of decisions made by someone other than the individual under observation. Furthermore, the individual being rated may not have the freedom to choose the practices he is to employ. He may "know" better than he "does." In these cases the evidence does not reflect his own understanding.

Explaining How and Why the Selected Practices Are Performed

The extent to which the swine producer has carried out the practices in correct order, at the proper time, and with productive skill is a reasonably valid measure of his understanding of the importance of timing and the relationship of the practices to each other and to the attainment of good results. When good results are attained, if the individual can explain his production methods and give the reasons for using those methods, convincing evidence of understanding is available. For example, does he know why it is advisable to flush the sows before breeding and to "haul" the sow and litter from the central farrowing house to the clean-ground pasture rather than to drive them through the old lots? If he can tell you "why," you can be more certain that he understands not only the relation of practices to results but also the reason or facts and principles which enable him to achieve the desired results.

The Use of Old Information in Situations That Are New to the Individual

Still more convincing evidence of understanding is the application of information to problems new to the student. The individual who understands the principles of sanitation in hog farrowing, for example, and who, on the basis of his knowledge of these principles, works out good practices of sanitation in poultry raising is exhibiting understanding of a high order.

Types of behavior such as have been described imply understanding. They are the kinds of evidence one looks for in measuring understanding. Before one can measure something, he must find it. Before he can know when he finds it, he must know what he is looking for. Hence, a clear picture of what individuals do that is the result of understanding is necessary before understanding can be validly measured.

Illustrative Procedures for Measuring Understanding

Measurements are not, of course, limited to the use of numerical units. Some of our most important objectives of teaching cannot yet be measured numerically. Descriptions of behavior and results are most useful in these cases as evidence of achievement and growth toward the objectives.

This broad view of the word "measurement" enables the teacher to use informal methods of appraisal such as observation and inter-

view in the everyday situations of the school and during a home-farm visit. A day is full of these situations which a teacher can use for the purpose of evaluating understanding.

The use of a small record form on which these observations can be recorded has been found helpful. These forms are called *anecdotal records* because they describe episodes in the normal life of the person observed. In making observations or holding interviews, it is helpful to have these questions in mind always, "Does the evidence show *his own* understanding?" "Could the evidence be the result of some other person's understanding, not that of the boy himself?" "Did he do the best he knew how?" It is necessary to keep probing until the answers to these questions are obtained. Needless to say, the probing should not be done too obviously. It may become objectionable to the pupil, your chance of getting conclusive evidence being lost on this account. Or the boy may deliberately try "to cover up" his lack of understanding and mislead you intentionally. Such efforts can usually be detected in the evasive or inconsistent answers to which the pupil has recourse. However, the lack of good hearing, a language handicap, or a desire to please may result in answers that are inconsistent. Then, too, the pupil may not be able to express himself adequately in words. These things should be kept in mind for the sake of insuring reliable evidence of understanding and avoiding misinterpretation. It is always hazardous to jump to conclusions too quickly. There is often more behind the scenes than appears on the stage.

Additional means of measuring understanding are, of course, available in the form of *performance tests* and *pencil-and-paper tests*. They have their limitations and are not ordinarily used in out-of-school situations such as farming. They are very useful, however, in getting a record of behavior in many situations in a relatively short time. The following are examples of pencil-and-paper tests of understanding.

Example: A farmer wishes to market his spring crop of hogs before the usual market drop in price. What practices will help him to do this? Give your reasons for recommending these practices.

In this test exercise, the individual writes his answers. He is expected to state the practice which will help the farmer to get the result he wants and to explain his recommendations in terms of pertinent facts and principles. The same test exercise can also be set up in multiple-response form to facilitate administration and scoring and still

maintain a high degree of correspondence to the results secured by using the longer essay form.[2]

Example: [3] A farmer wishes to market his spring crop of hogs before the usual drop in market price. Which of the following practices will help? (Check one or more.)

_____ 1. Have pigs farrowed in March or early April.
_____ 2. Have pigs farrowed late in May.
_____ 3. Put brood sows and litters on pasture with self-feeders of shelled corn and tankage in separate compartments.
_____ 4. Wean the pigs at six weeks of age.
_____ 5. Provide self-feeders after weaning.
_____ 6. After weaning, put pigs in dry lot and feed entirely on corn.
_____ 7. Limit the feed during the summer and have hogs fatten on fall crops of corn.

Reasons: (Check the statements below which represent your reasons for choosing the practices you checked in the preceding list.)

_____ *a.* The usual market drop which affects the spring crop of hogs starts in September.
_____ *b.* The usual market drop which affects the spring crop of hogs starts in November.
_____ *c.* Under favorable conditions hogs will be ready for market at six months of age or less.
_____ *d.* Hogs gain most rapidly when hand fed.
_____ *f.* Hogs can usually be produced most cheaply on a limited grain ration for the first few months, followed by heavy feeding.
_____ *g.* Brood sows and their pigs are able to balance their own ration when provided "free choice" of tankage and corn.

This kind of test exercise can be constructed by choosing a problem situation and listing various practices which students probably have in mind, together with the facts and principles which explain the practices. This exercise should give the student an opportunity to check the things he would write in an essay test, thereby saving time in administering and scoring the test. It should contain both right and wrong practices and reasons substantiating good practice.

Another type of test exercise is that in which computational skill is required in arriving at a solution of the problem. Two examples of this type are shown as follows.[4] Both require an understanding of the relationship between the things to do and the result.

[2] Fred P. Frutchey, "Illustrative Test Exercises in High-School Chemistry," *Educational Research Bulletin,* XVI (May, 1937), 122-26.

[3] Adapted from G. P. Deyoe, "Test for Understandings and Problem-Solving Ability in Agriculture." Danville, Illinois: Interstate Publishers, 1937.

[4] Adapted from Deyoe, *ibid.*

Problem 1. The following amounts of milk, with the butterfat tests as shown, are mixed together. What would be the butterfat test of the combined amount?

215 lbs. testing 3%
240 lbs. testing 4%
50 lbs. testing 5%
20 lbs. testing 6%

Problem 2. A farmer is planning to fatten lambs on a ration of alfalfa hay, silage, and shelled corn. He wonders if it will pay to add small amounts of linseed meal to the ration. He reads in a bulletin that experiments have shown that by adding one-sixth pound of linseed meal per head per day to the above ration, 100 pounds of linseed meal will save 132 pounds of corn, plus 114 pounds of hay, plus 100 pounds of silage. What is the highest price per hundred pounds which this farmer could afford to pay for linseed meal with corn at two cents per pound, hay at one cent per pound, and silage at one-third cent per pound?

In the scoring of computation problems, some margin of variation should be permitted on account of differences due to rounding-off figures.

Another type of evidence of understanding is the ability to criticize, when the criticisms indicate ability not only to point out mistakes but also to suggest proper practices. An individual who can examine a result or a procedure, diagnose the difficulty, and suggest the appropriate remedy understands the relationship between the practices employed and the desired result. The following exercise illustrates this type of behavior.[5]

Example: The man from the county fair association visited a rural school. He gave a talk on boys' and girls' exhibits which he hoped to start at the fair in the fall. Arthur Jackson, who attended this school, became very interested. Arriving home from school that night, he told his parents all that he could remember about what the visitor said. After talking things over with his parents and conferring with the representative of the fair association, Arthur decided to raise a dairy calf to exhibit at the fair. He bought the calf and took care of it to the best of his ability. At the end of the year he wrote his story of how he selected and raised this calf. Here is his story. (You are to read Arthur's story and then write a list of all the mistakes you think Arthur made.)

"It was in June when I decided to raise a calf for the fair exhibit. Dad and I visited our nearest neighbor, who had a modern dairy farm and who had a Jersey dairy calf for sale, which was being fed on skim milk. We liked

[5] Fred P. Frutchey, and Harley A. Leland, *Educational Growth in the 4-H Dairy Project, Massachusetts.* U. S. Department of Agriculture, Extension Service Circular No. 369. Washington: Government Printing Office, 1941.

the calf so much that we bought it immediately without asking any further questions. It was two weeks old and cost only $5. I discovered later that it could not be registered. We took the calf home and I tied it in the field under the apple tree where it could get plenty of green grass and shade. I continued to give it warm skim milk three times a day, as our neighbor had been doing, and started feeding a handful of grain, which I put in a small box fastened to the tree. The calf grew well, and I taught it to lead. She would stand and pose for my friends. She became quite a pet.

"The day before the fair I brushed my calf well and fixed up her horns. Then I put a blanket on her which was made from an old rug so badly worn that it could not be used in the house. Just before I was to leave for the fair I received word that I could not show because my calf was not registered. I felt pretty badly about it, but since there was nothing I could do, I turned the calf out to pasture with the cows and left it until cold weather. This is all I have to tell of my year's work. I hope that next year I shall have better success."

What mistakes did Arthur make? What should he have done? Write your answers to these questions.

Understanding is also indicated in the manner, speed, and sequence of performing various skills to obtain a desired result. Explanation of the "how" and "why" of each step gives further evidence of understanding the relationship between the things done and the end product. An example of a performance test is a demonstration of skill in setting out trees and shrubs.[6] The behavior to be observed in this test involves the exercise of the skills necessary to execute the plans formulated. Several operations are required. There are three important elements in each operation. These are quality, time, and sequence.

Example: (Directions to person in charge of giving the performance test.)

Provide the following material at the approximate location at which the tree is to be planted: one hardwood tree about 10 feet high, one pick, one spade, one shovel, one "tamper," 300 lbs. of well-rotted barnyard manure, 3 guy wires, 3 stakes, 2 yards of burlap, one pair of hand pruning shears.

Direct the student to set out the tree with the use of one or more members of the class as assistants where help is needed. Check and record the time from the start until all operations are completed. Using the accompanying form for recording observations of procedure, observe his actions and check the quality of each action as, for example, good, fair, poor, in Column A. In Column B, write the time when the action was completed. In Column C, trace his actions by placing a figure 1 after his first action, a figure 2 after

[6] Adapted from A. C. Aderhold and G. F. Ekstrom, "A Suggested Technique for Constructing Tests in Vocational Agriculture," *Agricultural Education Magazine*, X (January, 1938), 136-37.

his second action, and so on, in the order of performance of the different operations. In Part II, check the noticeable characteristics of the student's behavior.

PART I: SKILLS

Student's Actions	A Quality	B Time	C Sequence
1. Locates according to plan			
2. Lays out diameter of hole to fit root system of tree			
3. Loosens soil with pick (if necessary)			
4. Removes dirt with spade or shovel			
5. Makes separate piles of surface soil and subsoil			
6. Digs hole six inches deeper than tree originally stood			
7. Mixes 4-inch layer of equal quantities of rich top soil and manure and places in bottom of hole			
8. Tamps mixture			
9. Prunes all broken and bruised roots			
10. Places tree in hole two inches deeper than in nursery			
11. Places tree so roots lie normally			
12. Holds tree erect			
13. Places top soil in hole with shovel			
14. Tamps soil after addition of each four inches of soil			
15. Mulches a circle around tree by mixing barnyard manure with top six inches of soil			
16. Leaves saucer-shaped depression around base of tree			
17. Drives three stakes for guy wires in triangle fashion about 6 feet from tree			
18. Places guy wires, with hose protections, above branches about 5 feet above ground			
19. Wraps burlap around trunk and ties with strong cord			
20. Removes broken and diseased limbs			
21. Makes smooth, clean cuts			
22. Prunes to balance the tree			

After the tree has been planted, ask questions that will give the student an opportunity to explain why he performed certain actions as he did and why the operations performed followed the particular sequence. For example, "I noticed you tamped the top soil and manure mixture in the bottom of the hole. Why?" From an examination of your notations in Parts I and II, make a list of actions and other aspects of the student's behavior that you think he could improve and record these items and suggested remedies in

the space provided for "Comments." Also record any improvising which seemed to reflect understanding on the part of the student.

PART II

Noticeable Characteristics of Student's Behavior	Check
1. Awkward in movements	
2. Slow and deliberate	
3. Obviously perturbed	
4. Does not take work seriously	
5. Unable to work without specific directions	
6. Obviously satisfied with his unsuccessful efforts	
7. Exercises care in handling tree	

COMMENTS:

Understanding is evidenced by the drawing of reasonable inferences from agricultural information and by distinguishing among interpretations which are entirely supported by the data, interpretations which are partly supported by the data, irrelevant interpretations, interpretations which are probably false, and interpretations which are entirely false according to the data. Examples of similar types of test exercises in the field of science are presented in chapter vi, and examples of exercises measuring understanding of social and economic problems can be found in chapter v. Many of these can be adapted for use in agriculture.

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CHAPTER XV

THE MEASUREMENT OF UNDERSTANDING IN TECHNICAL EDUCATION

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OBJECTIVES IN TECHNICAL EDUCATION

The industrial progress of a nation is accompanied by an increase in the use of power. The processes which require manual labor are replaced by inventions of labor-saving and time-saving machines and devices which make possible increased production with decreased physical exertion by the individual.

However, with this decrease in demand upon the physical exertion of the individual comes an increased demand upon the technical worker's mental ability and ingenuity to design, manufacture, test, distribute, and then maintain the many newly created devices which have caused this evolution in the mode of living.

The 1944 report of the consulting committee on Vocational-Technical Education,[1] appointed by the U. S. Commissioner of Education, makes the following statement of the need that technical education at the secondary level attempts to fulfil.

"The rapid expansion of technology is creating new needs for training. New materials, new processes, and new products are being developed at increasing rates. Demands of the war for trained technicians have stimulated new training programs. Technological developments in industry are increas-

[1] *Vocational-Technical Education for Industrial Occupations*, pp. ix, x. U. S. Office of Education, Vocational Division Bulletin No. 228. Washington: Government Printing Office, 1944.

ing the need for technically trained personnel, in the opinion of nearly 80 per cent of the industrial representatives interviewed. . . . .

The number of technicians required as compared with the number of college-trained engineers, from data gathered in sixteen states, is reported to be an average ratio of 5.2 technicians per engineer. . . . .

The present situation in industry warrants a large expansion of vocational-technical training programs.

The term "technical education" as used in this yearbook refers to that given in secondary schools. The objectives of technical education listed in the chapter do not cover all those of professional engineering and scientific specialist training which require four years of college study. Some of the objectives listed apply only to technical education at the secondary level.

Because of the sporadic growth of technical education in this country and its relative newness on the secondary level, perplexed interpreters of technical-industrial education ascribe to it a variety of aims and purposes.

According to the American Association of Technical High Schools and Institutes [2] and the New York State Education Department,[3] technical-industrial education is planned to prepare the student for technical and semiprofessional jobs of the following type: laboratory technician, shop foreman, junior chemist, junior draftsman, test-equipment operator, engineering producers salesman, inspector of industrial equipment, specialized industrial-equipment operator, industrial-plant supervisor, and serviceman and trouble diagnostician.

Although the technical high-school curriculum is organized to contribute to some of the objectives of the academic secondary school as well as to some of those of the trade school, this chapter does not give consideration to the objectives of general education or to those concerned with the development of hand skills.

Rather, the chapter is confined to a consideration of the evaluation of the following special outcomes of technical education which are based on a study of the 1944 Federal Report of the Advisory Committee on Vocational-Technical Education,[4] the recommendations of

[2] American Association of Technical High Schools and Institutes Yearbook, 1946. (In manuscript form. Information available from W. E. Stirton, Principal, Cass Technical High School, Detroit, Michigan.)

[3] *The Organization and Administration of Technical Courses in Secondary Schools,* Bulletin of the University of the State of New York, No. 1086. Albany, New York: University of the State of New York, 1945 (Revised).

[4] *Vocational-Technical Education for Industrial Occupations.* U. S. Office of Education, Vocational Division Bulletin No. 228. Washington: Government Printing Office, 1944.

several technical curriculum-construction committees of the New York State Education Department,[5] and the statements of the American Association of Technical High Schools and Institutes as set forth in the 1946 Yearbook:[6]

1. *Understanding and mastery of the fundamental bodies of knowledge and principles of science and technology which are essential for vocational competency in such technical and semi-professional jobs of the type listed on p. 282; in other words, an understanding of the methods of using materials and energy.*

For example, a technician in the field of radio service needs to be more than a radio mechanic who is able to replace defective parts in a radio. He should have such an understanding of the principles of electricity as applied to the operation of a radio that he is able to diagnose the trouble from the symptoms. Another example would be that of a graduate of a technical course who is working in the control section of a chemical manufacturing plant. He should have such an understanding of the processes of manufacturing that he will know how to take the necessary samples and know what chemical analyses are needed to control the quality and quantity of the manufactured product. He must understand the principles of chemistry involved so that his analyses need not follow in a routine fashion the step-by-step procedure for analysis given in a textbook.

2. *An understanding of the sketches, drawings, and specifications made by the engineer or architect so that one may be able to produce or supervise the production of the article designed.*

For example, the graduate must be able to interpret blue prints and specifications so that he can carry out the plans of the engineer or architect. This means not only that he must be able to interpret drawings, but also that he must understand the functions and operation of production equipment so that he can produce or supervise the production of the finished product. If a drawing is furnished calling for 1,000 pieces of an article, he needs to understand how these can best be produced. For instance, he needs to know if the article can be forged or whether a pattern and a casting are needed. He also needs to know if a jig is advisable and, if so, how this jig should be constructed.

3. *The ability to create simple designs from sketches or word descriptions supplied by the engineer or architect through an appreciation of the principles of drawing and technology.*

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[5] *The Organization and Administration of Technical Courses in Secondary Schools, op. cit.; Syllabus in Technical Subjects.* Albany, New York: University of the State of New York, 1941.

[6] *Op. cit.*

For example, the architect, after sketching the design of a one-family dwelling, may ask the technical high-school graduate to prepare the detailed working drawings of the dwelling and specify the sizes of each construction member. Therefore, the technical student must acquire an understanding of the details of building construction, including a knowledge of building codes, standard practice, and strength of materials, and have a mastery of technique of drawing.

If the student has completed a course in mechanical design, the engineer may give him a rough sketch of a part to be produced and ask him to compute exact sizes and make a detailed drawing for shop use. This involves an understanding of instructions given by the engineer and a mastery of drawing technique and of the simpler principles of design.

4. *A mastery of the fundamental processes of reading, writing, speaking, and mathematical calculation.*

The need for accuracy in calculations is obvious. Likewise, the need for understanding of instructions involving the printed word and drawings cannot be overemphasized. In addition, the desirability of mastery of use of the English language, both written and spoken, should not be overlooked. The ability to write clear, accurate reports is a particularly important outcome of technical education, as is also the ability to give clear oral explanations and issue oral instructions.

5. *Development of a background in technology necessary for advanced education and advanced work in industry.*

In a democracy, it is desirable to conduct technical courses in such a way as to provide a foundation upon which to build for future advancement. This means that in a technical high school the instruction in English, mathematics, and science should be adequate to meet the needs for admission to engineering college. Furthermore, the instruction in the technical subjects should be so basic, broad, and thorough that the graduate is prepared not only for entrance upon his first job, but also for advancement to a better job as he gains experience.

6. *Development of skill and technique in handling scientific equipment and an understanding of the principles underlying its operation and use.*

It is not sufficient for the student of technical education that he know how to use scientific instruments by rule-of-thumb methods. He must also know the principles upon which they are constructed and the theory underlying their use. For example, he should not only know how to use an ammeter for measuring the current in a circuit, but he should also understand the electrical and mechanical principles underlying its

operation; moreover, he should understand the merits of any selected instrument over other instruments and the accuracy of measurement which may be expected of it.

7. *Development of the ability to solve problems by a systematic and scientific procedure, which includes the consultation of all available sources of information. A corollary to this objective is the need of suspending judgment until all available data have been collected. A related objective is that of understanding the need for the careful planning of all work.*

For example, the design of a gear for a given purpose requires the careful and systematic examination of the problem and the consultation of sources which summarize the available empirical information on the suitability of different types of gears for transmitting a given horsepower at a given speed. This procedure is in contrast to the hit-and-miss methods of the amateur.

8. *Development of the social understandings necessary for leadership.*

Since many positions open to the graduate of technical education require the ability to lead and supervise others, it is important that the student acquire a proper perspective of his responsibilities and attitudes toward any group of persons with whom he works and associates.

Illustrative Procedures for Evaluating Understandings

It is quite impossible within the limits of this chapter to suggest comprehensive methods of evaluating all of the objectives previously listed. It is necessary, then, to limit subsequent discussion of evaluative techniques to a few illustrations in a few areas.[7] In some of the illustrations the material has been fairly completely developed, while in others the suggestions constitute only a rough guide for building usable instruments.

A common situation encountered by the technical student is one in which he is faced with a practical problem, such as that of carrying out a test on a machine, designing a structure or a machine which will do a given job, or carrying out a scientific experiment to test some hypothesis. The evaluative techniques which follow refer to such situations and illustrate methods of evaluating the student's understanding of various aspects of them. First, consideration will be given to the evaluation of the student's understanding of how to plan his work.

[7] In connection with Objective 4 the reader will find helpful suggestions for evaluation in chapter ix (Language Arts) and in chapters vii and viii (Elementary Mathematics and Secondary Mathematics).

Second, examples will be given of techniques for measuring the student's understanding of technical problems, the methods of solving them, and the instruments and devices used in this process. Third, techniques are illustrated for measuring understanding of drawings and specifications related to shopwork. Fourth, instruments are presented which measure understanding through evidence supplied by a student's performance in solving a problem of the comprehensive type. This illustration is followed by a discussion of the use of rating scales for recording a student's estimated level of understanding. Fifth, an example is given of the measurement of understanding through the examination of the student's creative work. Finally, the chapter concludes with a discussion of the measurement of social understanding related to foremanship and leadership in the shop.

Evaluating the Student's Work Plan

Every teacher is familiar with the difficulties which students encounter in planning their practical work. Most teachers attempt to organize instruction in such a way that the student comes to each period of practical work adequately prepared to carry the task through to completion. Many workbooks are designed to help the student approach each period of practical work with an adequate understanding of the work expected of him, but too often the net result of the workbook is to enable the student to go through a mechanical routine with little or no understanding of what the work involves. Unfortunately, it usually happens that the teacher does not become aware of the student's inadequate understanding of the practical work until it is reflected in a poorly organized and inadequate report. Much can be done to increase the value of practical work if a systematic attempt is made to check the degree of understanding with which the student approaches each practical situation and the extent to which he is capable of planning his work.

While objective tests could be developed in order to determine whether each student begins each task with a sufficient understanding for the *effective planning* of his work, such tests are laborious to construct and time-consuming to administer. The teacher can learn much about the adequacy of the student's preparation by observing him and by questioning him. Such observation and questioning can be systematized by the use of a check list including the points which the teacher should attempt to observe. Such a check list may also be useful in evaluating the student's readiness for a particular task and in ascertaining the adequacy of the *work plan* of individual students who have difficulties with their work. The following list illustrates the types

of items that may be used in a check list of this kind. The teacher should develop for each item in the list a series of questions to be directed to the student and a list of answers which are to be considered as acceptable.

1. Does the student know the reason for the experiment or the object of the work?
2. Does the student know what tools and equipment are required? (Make a check list.)
3. Does the student know what materials are required? (Develop a detailed check list.)
4. Does the student know what operations are required? (Develop a detailed check list.)
5. Does the student know the best sequence of operations?
6. Does the student understand the operation of the equipment?
7. Does the student know the accuracy required in the results?
8. Does the student know the main sources of error?
9. Does the student know the limits of accuracy of the equipment?
10. Has the student made adequate provision for recording his results?
11. Does the student know what facts should be recorded in addition to the quantitative observations?
12. Has the student consulted any necessary reference works?
13. Does he know what precautions should be taken to protect the equipment and himself?
14. Does he know where to obtain all the necessary materials and equipment?

It is obvious that such a check list cannot be used to check every student on every occasion, but it can be used at intervals in individual cases. While many teachers believe that such a check list should be scored, in the opinion of the writers its main value lies in its use as a means of systematizing the teacher's observations.

It is evident that it is necessary to adapt the check list to the special requirements of each period of practical work. It is possible to use such a check list for the systematic investigation of the adequacy of the understanding with which students plan their work. An additional value of a check list of this kind lies in the fact that it supplies the teacher with a guide which can be followed in preparing the students for their practical work.

The Measurement of Understandings Related to a Technical Problem

A superficial analysis would indicate that the best way to determine whether a technical student has understandings of the type noted in Objectives 1 and 7 would be to observe his behavior in the actual situation which he encounters in the laboratory. Certain precautions

should, however, be observed. Although the student usually makes errors in handling a practical problem which provide evidence that he has failed to understand certain specific aspects of the situation, a student may, nevertheless, be able to give a faultless performance—not because he has insight and understanding, but because he is able to follow the routine described in a book. Most of the more common chemical tests or engineering tests on materials and machines can be carried out fairly easily by one who knows the routine but who may not understand the principles underlying the process. Consequently, while the teacher may obtain some evidence of the student's understanding of a practical problem by observing and questioning him while he is working, the systematic measurement of the student's understanding of this situation must wait until the student has completed his work. Once the student has completed his work on the problem, it is then possible to give him an over-all rating for his performance on the particular problem, or to measure understanding of the problem through objective tests.

The following illustrations suggest the use of objective test items to measure the student's understanding of principles underlying the operation of industrial equipment similar to that which he has used in the laboratory (Objectives 1 and 6).

In the first example, it is assumed that the student has received classroom instruction on the theoretical aspects of the problem of measuring the brake thermal efficiency of a standard gasoline engine and that the student has also had the opportunity to apply this theory by operating a standard automobile gasoline engine in the power laboratory, recording the necessary data, and calculating the brake thermal efficiency.

Test items such as the following may then be employed in the measurement of understanding. Items 1 to 3 are based on the following situation:

Example: A brake thermal efficiency test is being conducted on an 85-horsepower, 8-cylinder automobile gasoline engine.

1. A load applied to the engine reduces its speed from 2,000 to 1,500 R.P.M. If the engine is *not* overloaded, its speed may be restored to 2,000 R.P.M. by decreasing the
   a. pressure in the fuel line
   b. compression ratio
   c. pressure in the carburetor venturi
   d. fuel to air ratio
2. The part of the operating cycle at which the pressure in the cylinder of the gasoline engine is greatest is

a. at the end of the compression stroke
b. near the beginning of the power stroke
c. at the end of the power stroke
d. at the beginning of the exhaust stroke

3. When an increase in the compression ratio of a gasoline engine results in an improved brake thermal efficiency, this is accompanied by an increase in the
   a. heat value of the fuel
   b. maximum temperature resulting from combustion in the cylinder
   c. octaine rating of the fuel
   d. maximum temperature of the exhaust gases

The next series of objective test items is planned to illustrate how objective test items may be adapted to the evaluation of the student's comprehension of laboratory procedure in industrial chemistry. Items such as these could be used to determine the extent to which the student understands laboratory procedures of the type covered in the problem. (Objectives 1, 2, and 6 are involved in the student's total comprehension of the problem.) Questions 1 through 5 are based on the following problem:

Example: To prepare a 100-pound batch of liquid soap meeting the following specifications: (1) two degrees Baumé at 20 degrees centigrade; (2) free alkali not to exceed 0.05 per cent potassium hydroxide; (3) raw materials as follows: cocoanut oil; potassium hydroxide, 47 degrees Baumé solution; oleic acid, as needed; perfume, as desired.

1. The main reason for using potassium hydroxide in this process instead of sodium hydroxide is to produce a soap which is
   a. hard
   b. neutral
   c. soft
   d. saponified

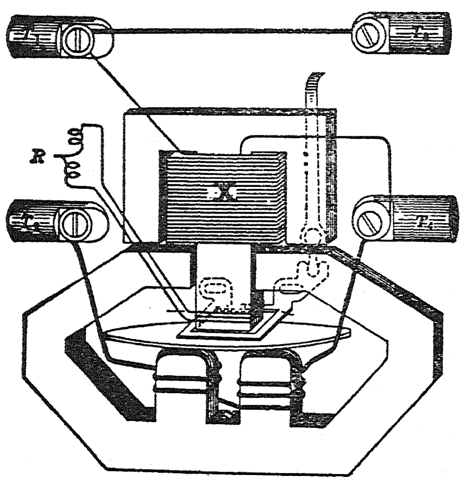
2. One reason why it is necessary to control carefully the alkalinity of the soap produced is that an excess of alkali produces
   a. hydrolysis
   b. precipitation of grease
   c. a soap which irritates the skin
   d. a soap which does not lather

3. One reason why potassium hydroxide is used instead of calcium hydroxide in making liquid soap is that the latter would produce a soap which is
   a. brown
   b. acid
   c. insoluble
   d. viscous

4. What is the approximate number of kilograms of potassium hydroxide required to react with 2 kilograms of cocoanut oil if its saponification number is 260?
   a. 52 kg.
   b. 0.26 kg.
   c. 130 kg.
   d. 0.52 kg.
5. Before attempting to make a 47 degree Baumé solution of potassium hydroxide it is necessary to determine the
   a. heat of solution of potassium hydroxide
   b. degree of ionization of potassium hydroxide
   c. solubility of potassium hydroxide
   d. percentage of potassium hydroxide in such a solution

The following sample test illustrates how the objective type of test procedure may be used to measure the student's understanding of the way in which an instrument operates (Objective 6). Questions 1 through 4 are based on the following diagram of an induction watt-hour meter.

Example: Check the statement that indicates the correct answer to each question based on the following drawing.



1. What is the function of the coil marked X?
   a. It produces a magnetic flux proportional to the line voltage.
   b. It exerts a retarding torque on the rotating disc.
   c. It adjusts the instrument for lag.
   d. It exerts a torque proportional to the load.

2. What is the effect on the rotating disc of placing a strong magnet near the rotor?
   a. The speed of rotation is retarded.
   b. The speed of rotation is accelerated.
   c. The speed of rotation is unchanged.
   d. The speed of rotation is either retarded or accelerated, depending on location of the magnet.

3. One common way of making the lag adjustment is to adjust the
   a. resistance of *R*
   b. position of the drag magnets
   c. position of the disc
   d. resistance of the current coils

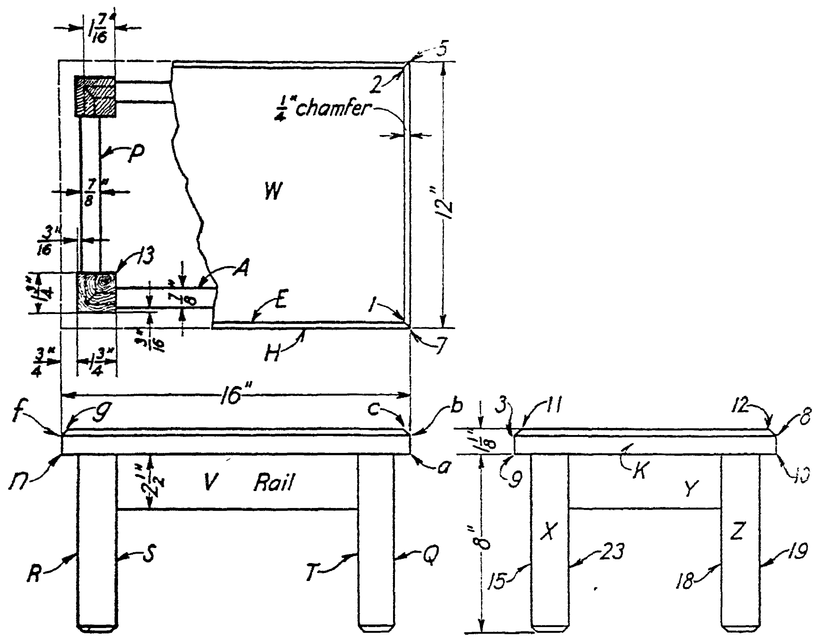
4. Which one of the following does *not* change in magnitude when the load is changed?
   a. the field around the potential coil
   b. the currents induced in the rotor
   c. the field around the current coils
   d. the torque exerted on the rotor

The Measurement of the Understanding of Drawings and Other Specifications

It is not always necessary to require the student to produce a specified object in order to determine whether he understands the specifications. Such a procedure tests not only the student's understanding of the specifications but also his ability to produce the given article. A satisfactory method of measuring understanding in this area (Objective 2) is to present the student with a set of specifications which are new to him and then to question him on his understanding of them. The questions may be of the multiple-choice or completion type. In the following example,[8] the student is presented with a technical drawing of an object which is to be produced, and his understanding of these specifications is determined by means of a series of questions. Sample questions are given here, but numerous additional questions could be asked. In each case, the student responds by selecting the correct edge or surface in the drawing, or by recording a numerical value of length or area determined from the drawing. The items can be objectively scored, and if machine methods of scoring are available, these items may be converted into the multiple-choice form.

[8] This drawing and the sample questions were developed by J. M. Gray of the Brooklyn Technical High School.

Example: Answer the questions concerning specifications for a stool as shown in the following drawing.



1. What is the dimension of the chamfer shown in the front view?
2. How much does the top of the stool project beyond the front leg?
3. Which point on the top view is represented by line S in the front view?
4. What is the distance between the inside of the legs in the side view?
5. What line in the top view represents the back surface of rail V?
6. What point in the top view represents point 10 shown in the side view?

A third method of determining the student's understanding of specifications is to ask him to complete the job called for by the specifications. While in some fields this is a very long and tedious procedure for measuring understanding, in other fields it may be a fairly economical procedure. For example, in order to determine whether a student can understand a wiring diagram, it may be sufficient to permit him to complete the actual wiring required. On the other hand, similar information may be obtained by the use of diagrams scored objectively and related to the original wiring diagram. When the student is required to fabricate an article, his score should be determined either by checking the product against the specifications or by checking his performance against a detailed check list at each stage in the procedure.

The Measurement of Understandings Involved in the Solution of the Comprehensive Type of Problem

In the examples given up to this point in the chapter it has been the practice to break down the various aspects of the behavior involved and to measure the student's understanding in a piecemeal manner. Many teachers feel that the behavior required of the student in such situations is fundamentally different from that where the student is required to solve a major problem involving a number of skills, understandings, and appreciations. The argument is that the student may acquire the isolated skills and understandings but still be unable to integrate them into the total behavior required for solving a comprehensive problem.

In the following examples the student is asked to solve comprehensive problems which require the synthesis of numerous understandings and skills. The student's understanding of these problems can be scored with objectivity by the use of the check sheet. An objective scoring device of this type is much superior to the more common practice of arriving at an over-all rating of the student's performance.

The comprehensive problems used to illustrate this technique have appeared on comprehensive technical regents' examinations administered to technical high-school students by the University of the State of New York.

Comprehensive Navigation Problem [9]

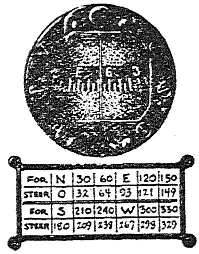
Example: A paratroop transport with air speed of 190 miles per hour is to fly from Leuchars, Fife, Scotland, to Bergen, Norway. The following data are given:

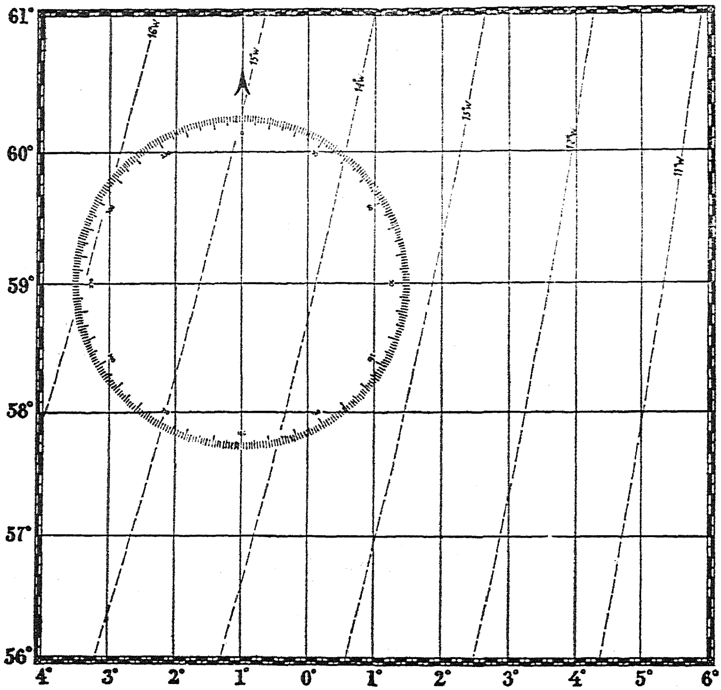
Leuchars	56° 17′ N	3° 00′ W
Bergen	60° 25′ E	5° 21′ E

1. Plot the two places and determine the true course and distance from Leuchars to Bergen.
2. If the compass heading and the deviation card are as given in the accompanying chart, what is the drift at the beginning of the flight?
3. How long would the flight take if a northeast wind were blowing?

This problem presents to the student a new and novel situation in which he is required to integrate his knowledge of operational procedures and his related understandings. The solution of such a problem will usually call for the use of skills. If the intent is to measure under-

[9] This problem was developed by F. J. Coyle, Brooklyn Technical High School.





standings, then the teacher constructing the problem must guard against the use of items which primarily measure the acquisition of skills. For example, the solution of the problem cited involves the use of many skills such as (1) reading a compass, (2) using a deviation card, (3) using a compass rose, and (4) plotting a position on a Mercator chart.

Although the performance of the operations enumerated are necessary to obtain the correct solution, a student may be capable of reading a compass or using a deviation card without being able to solve the problem presented. The successful solution of a comprehensive

problem requires the student to organize and execute a unified plan of action based upon understandings.

The following check list is provided for measuring the student's understanding of the problem. While this check list breaks down the student's behavior into a number of items it still permits the student to carry through to completion an integrated performance.

Examiner's Scoring Check List for Navigation Problem

	Yes	*No*
1. Is W. longitude designated to the left of zero degrees and E. longitude to the right?		
2. Is the position of Leuchars plotted accurately within one minute?		
3. Is the position of Bergen plotted accurately within one minute?		
4. What latitude scale did the student use to determine the distance from Leuchars to Bergen?		
a. 58° to 59°		
b. 56° to 61°		
c. 56°17′ to 60°25′		
5. Is the scaled distance from Leuchars to Bergen between 356 and 360 nautical miles? (Best answer, 358.7 nautical miles)		
6. Did the student specify nautical miles when stating distance?		
7. Is the true course from Leuchars to Bergen between 46°00′ and 47°00′? (Best answer, 46°41′)		
8. Did the student read the compass heading as 68°?		
9. Did the student use the variation at the starting point, Leuchars?		
10. Did the student add the variation correction to true course to obtain a magnetic course?		
11. Did the student ascertain the deviation correction to be 4° West?		
12. Did the student add the deviation correction to the magnetic course to obtain compass course?		
13. Did the student subtract compass heading from compass course to determine the drift?		
14. Did the student ascertain the drift to be a West drift? (Best answer, 3° West drift)		
15. Did the student use ground speed in determining the time of flight?		
16. Did the student correctly employ the wind triangle by:		
a. laying off the drift angle to the right of true course? . .		
b. laying off the air speed along the true heading?		

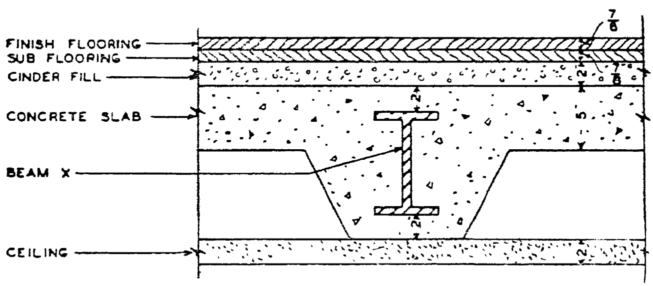
	Yes	No
c. assigning the wind vector a West, or left direction?...		
d. using the same scale for measuring ground speed as was used in plotting air speed?..................		
e. obtaining a ground speed between 177 and 181 statute miles per hour? (Best answer, 179 statute miles per hour)		
17. Did the student use consistent units?.................		
18. Did the student divide the distance by the ground speed to obtain the time of flight?.........................		
19. Was the time of flight between *2 hrs. 16 min.* and *2 hrs. 20 min.?* (Best answer, 2 hrs. 18 min.)................		

Comprehensive Structural Problem

The following problem in structural design [10] is also illustrative of the comprehensive type of problem employed to measure the understanding of technical principles.

Example: The student is asked to determine the required size of beam *X* shown in the figure. The following data are given:

1. Floor-to-floor height in the structure, 12′ 8″
2. Ceiling height, 11′ 0″
3. Floor construction as shown in figure:



4. Floor loads:

Live load	100 lb. per sq. ft.
Movable partitions....	18 lb. per sq. ft.
Finish flooring........	3 lb. per sq. ft.
Sub-flooring	3 lb. per sq. ft.
2-inch cinder fill	16 lb. per sq. ft.
5-inch concrete slab ...	60 lb. per sq. ft.
Total.........	200 lb. per sq. ft.

5. Weight of beam plus fireproofing assumed to be 120 lb. per linear foot.
6. Beams are placed 8 feet on centers.

[10] The authors are indebted to I. S. Abrahams, Brooklyn Technical High School, and to Clifton C. Flather, New York State Education Department, for assistance in the development of this problem.

7. Allowable fiber stress, 18,000 lb. per sq. in.
8. The vertical deflection shall not exceed that usually allowed for the type of construction shown.

Scoring Check List for the Examiner

	Yes	*No*
1. Was the load of the floor per linear foot of beam determined to be 1,600 lb?..............................		
2. Was the weight of beam, plus fireproofing, used to determine total load per linear foot acting on one beam?...		
3. Was the total load per linear foot acting on one beam found to be 1,720 lb?..............................		
4. Was the total load on one beam found to be 30,960 lb?...		
5. Was the maximum bending moment found to be 835,900 lb?		
6. Was the required section modulus found to be 46.4 inches cubed?		
7. Was the maximum allowable height of beam found to be 10¼ inches?		
8. Was a 10-inch wide flange, 45-lb. I-beam selected from the tables of the Steel Construction Handbook of the American Institute of Steel Construction?...............		
9. Was the actual section modulus of the beam determined from the tables to be 49.1 inches cubed?.................		

Additional items in the check list refer to the shear and deflection of the beam. Space does not permit the inclusion of the items here.

Use of Rating Scales in the Measurement of Understanding

If the student is required to complete a project during a single period of observation, the teacher should provide some general subjective evaluation of the performance which can be kept as part of the student's record. Such evaluations may become a feature of the regular teaching procedure and form a basis for the systematic observation of student behavior. Such a day-to-day system of appraisal was found to be of considerable value in the Army Air Forces Technical Schools and has been adopted on a compulsory basis throughout the schools of the Technical Command.

Example: The following table shows this particular system of grades and the interpretation that should be given to each of the scale values.[11]

[11] The principles of this grading system were developed mainly by Dr. Kenneth E. Clark and Lt. Charles P. Sparks.

Scale Value	*Interpretation*
5	Completed the job quickly and efficiently. Learned what to do, why to do it, and the relationship of this job to others being studied in the unit.
4	Completed the required job with little hesitancy. Learned what to do and understood generally the underlying principles.
3	Had a general idea of what was to be done. Finished the job but with minor errors of omission or commission. Made false starts, changes, and repetition. Was not sure of himself or of his product.
2	Was able with difficulty to complete parts of the job himself. Had an idea of what to do but lacked sufficient information or dexterity to complete all parts of the job. Understood very little of why he did the job.
1	Could not complete the job even with major assistance from the instructor. Did not know the parts of his job either by definition or by use. Had no understanding of why the job was to be done.

It should be noted, however, that when this grading system was introduced, it was also recommended that it be used only with those projects where it was possible for the instructor to observe individual performances and behavior indicative of understanding. It must be evident to every teacher that a scale of this kind can be employed only in a limited number of situations, as in the drafting room, shop, or laboratory, where the student provides evidence of understanding through overt behavior. It is also evident that when an instructor is directing a class of thirty students, it is impossible to make observations of any detailed character on every student during the work period. Under such conditions, it may be desirable for the teacher to avoid using the rating scale on all the students after every class period, rating just a few on each occasion instead. Unfortunately, there has been a marked tendency in the past to use such scales unwisely when they have been used at all.

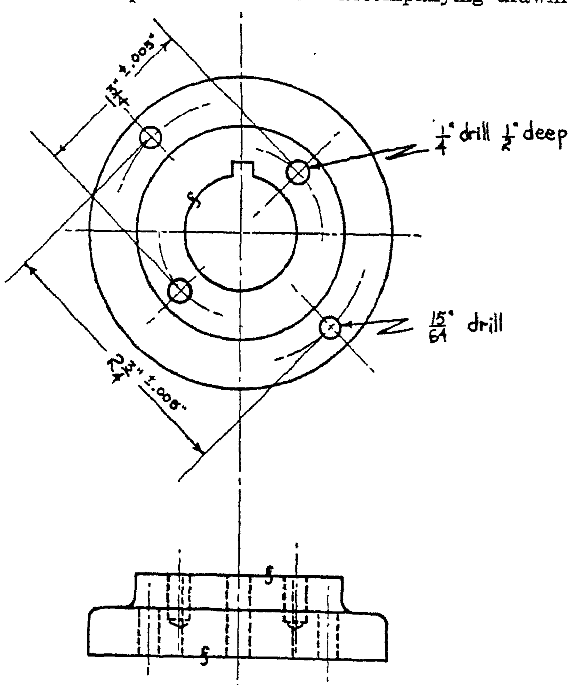
The Measurement of Understanding in Creative Work in Technical Fields

The student's work in technical training also includes numerous situations where it is necessary for him to develop a new procedure for performing a given operation or to design a new device which will perform a prescribed function (Objective 3). Such situations differ considerably from those in which the student is required only to understand certain specifications so that he may be able to produce the specified article. These latter understandings do not seem sufficient

to insure creative work although no satisfactory analysis has yet been made either of the intellectual abilities essential for such work or of the way in which these abilities are related to understanding. However, it seems to be generally agreed that satisfactory creative work in technical fields is symptomatic of a high order of understanding and that consequently such work may be accepted as evidence of understanding. The limitation of using creative work as evidence of understanding arises from the fact that it is generally difficult to establish a criterion of performance. In technical fields the criterion used to determine the value of creative work is largely a matter of whether the product will do a satisfactory job in the situation for which it was designed, and such a criterion is a much more objective one than any of those which can be applied in other fields of creative effort.

The following is an example of how a student's understanding of a problem may be measured through the product of his creative activity (Objective 3).

Example:[12] Design a simple drill jig for performing the last operation in the production of the part shown in the accompanying drawing. The last



[12] This problem and the check list were developed by Emanuel Rosenthal, Brooklyn Technical High School.

operation is to "drill all holes." One thousand parts only are to be made and XLO bushings ½" O.D. and ½" long are to be used.

The following check list may be used for scoring the design which is evaluated in terms of the extent to which it will perform the required function. Such a check list may be employed diagnostically to indicate gaps in the student's understanding of the principles of design. It should be noted that the student is still given some freedom in designing the jig, provided that it will perform the required job satisfactorily.

Check List for Scoring the Design of the Jig

	Yes	*No*
1. Did the student select the plug-type of jig?............		
2. Did the student design the jig with a plug and key to fit the piece part?.....................................		
3. Does the jig fit against the finished surfaces of the piece part?		
4. Is it possible to reverse the jig and drill from both sides?..		
5. Did the student design the correct bushing?............		
6. Were the bushing holes located 90° apart with respect to the center line?...		
7. Were the diameters dimensioned in decimals?...........		
8. Did the student insert a key in the plug to fit the piece part as a means of locking the work?..................		
9. Did the student draw both the top and the side views?...		
10. Was a partial section drawn to show the bushing?.......		
11. Were the locations of the holes given in degrees?........		
12. Did the student specify that the jig be made of C.R.S.?..		
13. Was the thickness of the jig plate equal to the height of the bushing?		
14. Was it specified that the jig be finished by grinding?.....		

Measurement of Social Understandings Related to Foremanship

Whenever the practical work is such that the students are required to work in groups, it is possible for the teacher to obtain evidence of each student's ability to act as a supervisor or as a student foreman (Objective 8). In evaluating a student's understanding of social situations, a check list may again serve as a useful guide for directing the teacher's observations. If the teacher looks for specific items of behavior which indicate the presence or lack of social understanding in the given situation, a much more satisfactory evaluation can be made than when the teacher attempts to make an over-all evaluation of the student's social behavior. The following items may be used as a

guide to the teacher's observation in the evaluation of the supervisory ability shown by a student working in a group situation.

Check List for Evaluating Supervisory Ability

	Yes	*No*
1. Does he consult the group in planning the work?.......		
2. Does he consult the other members of the group before changing the plans?		
3. Does he arrange for each member of the group to have a specific job?		
4. Does he consult the members of the group in assigning jobs?		
5. Does he delegate responsibility willingly?.............		
6. Does he do most of the work himself?................		
7. Does each member of the group know just what his task is supposed to be?.................................		
8. Are there any members of the group who are inadequately informed of the purpose of the work?................		
9. Are there members of the group who do not willingly follow his leadership?.................................		
10. Is there any duplication of effort within the group?.....		
11. Is the group as a whole kept informed of any developments that may affect them?.........................		
12. Does he bring to the attention of the teacher any outstanding contribution by a member of the group?......		
13. Does he make sure that each individual in the group receives the credit he deserves?........................		

It must be remembered, however, that such check lists have limited value in the quantitative measurement of student understanding. Their chief value lies in the fact that they are useful instruments for directing teacher observation in the identification of weaknesses in the student's understanding of technical processes.

CHAPTER XVI

THE MEASUREMENT OF UNDERSTANDING IN INDUSTRIAL ARTS

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In a broad sense, industrial arts is a part of general education for both boys and girls. The commonly accepted view of the nature and purposes of the industrial-arts program in the schools is characterized in the following excerpts from authoritative writings in this field.

Industrial arts is a phase of general education that concerns itself with the materials, processes, and products of manufacture, and with the contribution of those engaged in industry. The learnings come through the pupil's experiences with tools and materials and through his study of resultant conditions of life. It is a curriculum area rather than a subject or course, being comparable in this respect to the language arts (**1**: 1).

The industrial-arts work is justified not because the objectives of the industrial-arts teacher are essentially different from the objectives of the general-education teacher, but because the experiences provided in industrial arts offer a more effective and more economical means of developing certain desirable objectives which are given as the aims of general education than do the experiences provided in the so-called academic subjects. . . . In attaining many of the other objectives of general education also, the industrial-arts experiences are more effective than the experiences offered in academic subjects (**2**: 9).

A vast body of industrial information with which all men and women of true culture should be familiar is today being collected, organized, evaluated, and crystallized into a new school study, a study of industry from the social

as well as from the material side, a cultural study with the emphasis upon the how and why of industrial operations combined with a real appreciation of industrial life (**27**: 6).

Organized shop work as a part of the general education program of public schools is now in the third phase. . . . . The third phase, which we call industrial arts, has been developed because of the belief that pupils need to know more about their industrial environment and the bearing it has on their social, cultural, and economic life. We are now engaged in broadening the range of industrial arts in keeping with our rapidly changing industrial society.

In order better to interpret this environment, the practice has grown up of drawing from our ever-changing modern industry with its countless mechanisms, elements of experience which may be used for educational purposes in the school shop, especially by boys in the upper elementary grades and in secondary schools. The outcome of this new approach has been a gradual change from the formal discipline of manual training to a program of exploration. For the latter purpose we have shops and laboratories equipped for a wide range of activities involving the use of mathematics, tools, and machines representative of the activities and interests of a society which is dominantly industrial (**5**).

Industrial-arts students will give evidence of understanding, in a general sense, if they know how, why, and when to use the information and skills from their industrial-arts courses to meet new situations that arise in the school, the home, and the community. For example, if a boy's mother needs a new shelf in the cupboard, can he design one? If the faucet leaks at the kitchen sink, can a girl diagnose the difficulty and stop the leak? If the door bell will not work, can the boy or girl find the loose connection or defective transformer which is causing the trouble? If the family needs a new electric iron, can the boy and girl who have had industrial arts help select a well-designed, efficient, durable product?

Objectives of Industrial Arts

The following six goals summarize the teaching aims of industrial arts although the emphasis that is placed on these goals varies with the grade level, type of pupil, and community interests. Each of the goals involves a group or body of understandings, the nature of which is considered, in part, in the discussion of this section of the chapter and is revealed, perhaps more clearly, in the illustrative devices for evaluation.

1. *Ability to express one's self through planning and constructing projects, using common tools and a variety of construction materials, typical of industry.*

2. *Discovery of aptitudes and reactions contributing to the maturing of life interests, both of a vocational and of an avocational character.*

Industrial-arts teachers assume some responsibility in helping boys and girls to understand the possibilities for earning a living in the industrial vocations and the possibilities for avocations involving craft materials. The understandings that come in achieving this goal mature along with the boy or girl over a period of years and may continue on through adult life.

3. *Understanding of industry and its products and services, together with their influence in determining patterns of living in modern society.*

The modern school prepares for life and modern living, and has been greatly influenced by the machine age. The modern home of today is far different from the home of the pioneer. Industrial-arts teachers must teach boys and girls about industry, its processes, products, and services so that they may better grasp the fundamental workings of modern society.

4. *Ability to read and make working drawings for planning and constructing useful projects typical of modern industry.*

Industrial-arts teachers give boys and girls instruction in reading and making working drawings. This experience enables students to plan their work better and to work more intelligently from the well-thought-out plans furnished by skilled persons.

5. *The ability to choose industrial products with reference to design, pleasing color combinations, and durability; and to maintain and service such products.*

Goal five of industrial-arts teaching is constantly assuming greater importance. As the machine age continues to develop, people will more and more buy the things they need. This practice is quite different from that of the pioneer who made with his own hands and with simple hand-operated tools most of the items to meet his needs. The pioneer learned quality by working with tools and materials, but the people of today need training to help them understand the meaning of quality in the products of industry.

Many of the tools used in industry are complicated, expensive, and automatic. Few people can get a real appreciation of the way things are made merely by looking at them. On the other hand, training in the industrial arts gives them an understanding and appreciation of what constitutes quality in the products we need for modern living.

6. *Growth in abilities and attitudes related to mathematics, science, and the language arts, and to work habits, safety practices, and co-operation with others.*

Boys and girls who take industrial-arts courses have opportunities to broaden and strengthen their education in many related fields. Their vocabulary is enriched by adding the terms of industry. Their grasp of mathematical principles is strengthened by solving problems related to machines and construction material; their science is applied to practical situations through the study of machines and industrial processes; their reading and their use of both oral and written language are developed through use in new situations; also, there are numerous opportunities to develop leadership and social efficiency through working with others.

EVALUATIVE PROCEDURES

Examples of activities that are dependent on understanding and suggested techniques for evaluating understanding are given for the six major goals of industrial-arts teaching.

1. *Ability to express one's self through planning and constructing projects, using common tools and a variety of construction materials, typical of industry.*

The successful meeting of the following new situations by a boy or girl who has had industrial-arts training should indicate understanding as required by the first goal of industrial-arts teaching:

1. Plan, construct, and finish a desk for the home.
2. Plan and construct a plastic picture frame as a gift for mother.
3. Design, build, and finish a sand box for a smaller brother or sister.
4. Design, build, decorate, and finish toys for Christmas gifts.

The amount of understanding evidenced is directly proportionate to the student's ability to do the job on his own initiative, the time required to finish the job, the wise selection of materials, the type of construction used, the amount of material spoiled, the correct use of tools, and the condition of the tools.

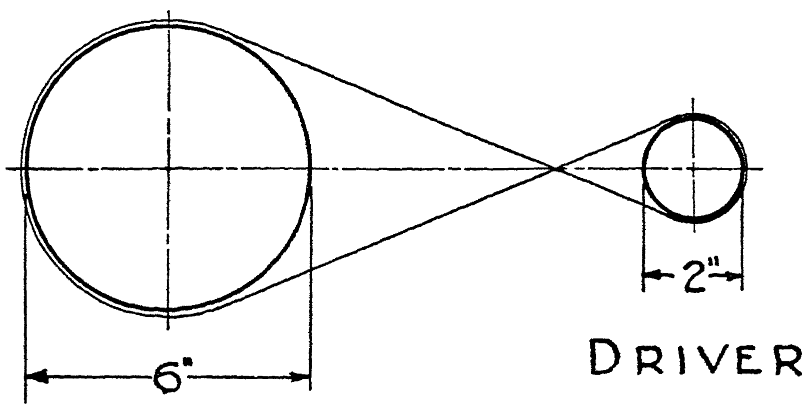
The boy or girl who has a good deal of understanding will have an adequate plan before he starts work, will have the work-space clean and well organized, the tools sharp and adjusted, the necessary materials at hand, and will proceed in an efficient, direct manner to do the job, using the correct tools in a workmanlike manner.

The real test of understanding in this case is ability to do the job, but certain glimpses or indications of a boy's or girl's understanding may be obtained through the use of test questions. The following types of questions are of some value in determining whether or not the indi-

vidual has acquired understandings basic to achievement of the first objective.

Examples of Essay Questions

1. In splicing No. 14 code wire, Bill Smith stripped off the insulation, twisted the wires together, and wrapped the splices with rubber tape. List the mistakes Bill made and tell why they are mistakes.
2. In refinishing old furniture the following steps are recommended: (*a*) apply varnish remover and scrape off old finish; (*b*) wash the surface with benzine and allow to dry; (*c*) sandpaper the surface; (*d*) stain to desired color; (*e*) apply varnish of average consistency; (*f*) apply thin varnish.
   (1) Why is it important to wash the surface with benzine?
   (2) If the wood is not sanded, what is likely to be the condition of the finished coat?
3. Describe briefly three important processes of applying a protective coating to sheet iron and steel. Discuss the relative advantages and disadvantages of the different processes or the conditions under which each is used.
4. The driver pulley illustrated below revolves clockwise at 1750 RPM. What is the speed of rotation of the shaft of the driven pulley? In what direction does it rotate? Explain your answer to each question.



Multiple Response Items

Check the statement which constitutes the best answer to each question.

1. Furniture makers prefer to work with mahogany rather than with oak because
   a. mahogany is heavier.
   b. mahogany does not require a filler.
   c. mahogany is less likely to chip (flake).
   d. mahogany is more plentiful.

2. In beginning the process of sawing off a board, the groove is made by pulling the saw backwards because
   a. the set of the teeth is such that the backward stroke is not likely to cause chipping.
   b. the set of the teeth is such that the saw will not cut on the forward stroke until a groove is provided.
   c. the saw teeth are sharper on the back side.
   d. you cannot put on pressure on the backward stroke.
3. In soldering electric wires together the function of the flux used is
   a. to soften the solder.
   b. to soften the wires.
   c. to clean the wire.
   d. to make the solder harden.
4. In making an end splice in No. 14 code wire, the purpose of soldering the wires together is
   a. to make the splice more permanent.
   b. to make electrical contact.
   c. to reduce electrical resistance.
   d. to insulate the splice.

True-False Test Items

Mark each statement to indicate whether it is true or false

1. A tap drill should be slightly larger than the bolt.
2. Quenching tool steel at the proper heat traps the carbon in solution.
3. Hacksaws and files cut on both backward and forward strokes.
4. A poorly sharpened drill tends to cut oversize.
5. The threads on a pipe are usually tapered.
6. A hammer should be used in preference to a mallet in forming articles over a sheet metal stake.
7. Each bolt and nut manufacturing company has its own standard for threads per inch.
8. The motor should be oiled each time you oil the rest of the machine lathe.

Example of Anecdotal Record

Teacher's note, October 8:

Noted that Fred tried his plane on a scrap board and then adjusted it before planing the board to be used in his project.

Fred started planing in the wrong direction. He stopped, examined grain of wood, then started to plane in the right direction.

Fred's trial of his plane and adjustment of that tool before using it on a good board shows that he understands that costly errors may be avoided and also shows that he understands at least one of the major characteristics of this tool. His reversal of planing direction after ex-

amining the grain of the wood showed that he understands some of the working qualities of the wood he was using.

Formal Observational Rating of Tool Techniques

Boys and girls who rate high on the following scale show evidence of understanding and of aptitude for the use of simple tools and material. Scales of this type are useful for a partial evaluation of understanding and as teaching devices. [The observer encircles the number which represents his quantitative estimate of the performer's skill: 1 for absence of skill; 10 for expertness.]

To Saw to a Line with a Rip and Cross-cut Saw

Tools and materials: Sharp rip saw and cross-cut saw, bench, wood vise, and piece of wood.

Directions: Observe pupil as he works, and rate him on the following points.

1. *Clamping stock:* 1 2 3 4 5 6 7 8 9 10
   Stock should be so held that it will not be loosened or cracked, and that its position will facilitate sawing.
2. *Starting cut:* 1 2 3 4 5 6 7 8 9 10
   With thumb at line, saw should be placed against the thumb. Saw should be pulled back slowly a few times to make a groove, then pushed forward.
3. *Holding saw:* 1 2 3 4 5 6 7 8 9 10
   Saw should be held firmly. For cross-cut saw, angle should be 45 degrees; for rip saw, 60 degrees.
4. *Stroke:* 1 2 3 4 5 6 7 8 9 10
   Stroke should be long and even, not too fast. Proper angle should be kept during sawing. Line should be followed.
5. *Ending cut:* 1 2 3 4 5 6 7 8 9 10
   The piece being cut off should be held with the free hand. Saw strokes should be slow and with little pressure so as to prevent breaking off the end.

Oral Questions and Discussion

1. Teacher: "Bill, why are you fastening those boards together now?"
   Bill: "So that I can see how to fasten the bottom board."

Bill's answer shows that he does not have a clear understanding of his project. He cannot visualize the completed work, and so gives evidence of only partial understanding. For instructional purposes, Bill's teacher has all the evidence needed. However, instruction at this point will not necessarily assure understanding on Bill's part. Most likely Bill's knowledge will reach only the level of mechanical skill. Therefore, the teacher should keep a record of his question and Bill's answer. Then, when a further test of Bill's understanding is desired, the teacher can confront him with a situation similar to this one.

2. Henry planned to make a simple bookcase and was ready to begin construction. His teacher asked, "Now tell me the steps in your plan." Henry gave a good step-by-step description. However, when dealing with material he merely stated, "I am going to need 16 feet 8½" x ¾" of white pine." At that point the teacher asked, "Does that allow for saw cuts?" Henry replied, "I'll need 7 pieces and their total length is 15½ ft. I figured that I need 6 extra inches to take care of saw cuts and squaring ends."

From this report the teacher could see that Henry had an understanding of the project he had planned.

Tests of Procedure

1. To rewasher a leaking compression faucet.

   Procedure:

   a. Examine the valve seat and ream if pitted.
   b. Shut off the water.
   c. Assemble the faucet, turn on water and test.
   d. Put on a new washer.
   e. Determine where the faucet leaks.
   f. Remove the valve stem.

   Directions: Rearrange the letters to show correct order of procedures and place in parentheses ( ), ( ), ( ), ( ), ( ), ( ).

2. To make a window screen.

   Procedure:

   a. Trim screen wire even with molding.
   b. Fasten the joints.
   c. Tack on the screen wire.
   d. Cut the stock to length.
   e. Determine the dimensions.
   f. Nail on the screen molding.

   Directions: Rearrange the numbers to show correct order of procedure and place in parentheses ( ), ( ), ( ), ( ), ( ), ( ).

2. *Discovery of aptitudes and reactions contributing to the maturing of life interests, both of a vocational and of an avocational character.*

Evidences of understanding related to this second objective are: an appreciation of one's ability or lack of ability with tools and machines; the enjoyment of leisure hours devoted to craft work; an interest in industry, its workers, and its products; a knowledge of the training necessary for success in industrial fields; an interest in the accomplishments of industrial leaders; a knowledge of and interest in the social and economic problems of workers and employers; a knowledge of the history of industrial developments in America and abroad.

Evidence of understandings related to this objective may be obtained by observation, interview, tests of aptitude, and evaluation of experience in industry or the crafts. Cumulative records, formal or informal, of each pupil's developing interests and competence are the primary basis for evaluating attainment of this objective and the attendant understandings. Test exercises are of some value in helping to focus more clearly the developing interests of boys and girls.

True-False Test Items

Mark each statement to indicate whether it is true or false.

1. Knowledge gained through boyhood hobbies is as useful as general shop training for an industrial vocation.
2. A machine operator requires more different kinds of training than a machinist.
3. Mechanical aptitude is necessary for one to become a skilled carpenter.
4. The skilled mechanic has been largely displaced by technological improvements in modern industry.
5. Iron was discovered before bronze.
6. Sheet metal is rapidly replacing wood in industry.
7. Manufacturers are paying increasing attention to providing comfortable and healthful working conditions for employees.
8. Practically all common articles now made of sheet metal are machine made.

Completion Exercise

Write opposite each occupational classification the amount of the annual wages such worker may expect to receive.

Occupation	*Annual Wages*
Laborer	______________
Machinist	______________
Carpenter	______________
Plumber	______________
Toolmaker	______________

Check List

Place a check mark in the proper space to show how much education each class of worker generally needs.

Worker	*Grade IX*	*Grade XII*	*College*
Laborer	_____	_____	_____
Delivery man	_____	_____	_____
Draftsman	_____	_____	_____
Mason	_____	_____	_____
Laboratory technician	_____	_____	_____
Engineer	_____	_____	_____

Matching Test

Match the worker with the job by writing the number of the worker in the blank space following the job with which he is associated.

Worker	*Job*	
1. Typesetter	Railroad	______
2. Pattern maker	Dressmaking	______
3. Cutter	Job shop	______
4. Steam engineer	Foundry	______
5. Oiler	Machine shop	______
6. Millwright	Planing mill	______
7. Sawyer	Carpet factory	______
8. Loom fixer	Factory	______

Another useful device, not illustrated here, is a rating scale on which the individual rates himself and is rated by other class members and by the instructor with respect to major aspects of competence in industrial-arts technique and on the basis of the interest and enjoyment he manifests in industrial arts.

3. *Understanding of industry and its products and services, together with their influence in determining patterns of living in modern society.*

Boys and girls give evidence of having the understanding necessary to attain the third goal of industrial-arts teaching when they take an interest in industrial processes and industrial life, express thoughtful opinions of the functions of capital and labor, and discuss sensibly mass production of consumer goods and the importance of price and wage levels for a prosperous society. Evidence of understanding may be obtained in many ways, e.g., by interview, observation, and class discussion. Essay questions also give some evidence of pupils' progress in mastering Goal 3 of industrial-arts teaching. Examples of such questions are:

1. Name five trades which are a part of the automobile industry.
2. Why are large steel mills located in Pennsylvania, New York, and Minnesota?
3. Compare furniture making as an industry in 1800 and 1945.
4. Explain why the city dweller of 1850 could not afford a horse and buggy costing $500, when he can own a $1,000 automobile today.

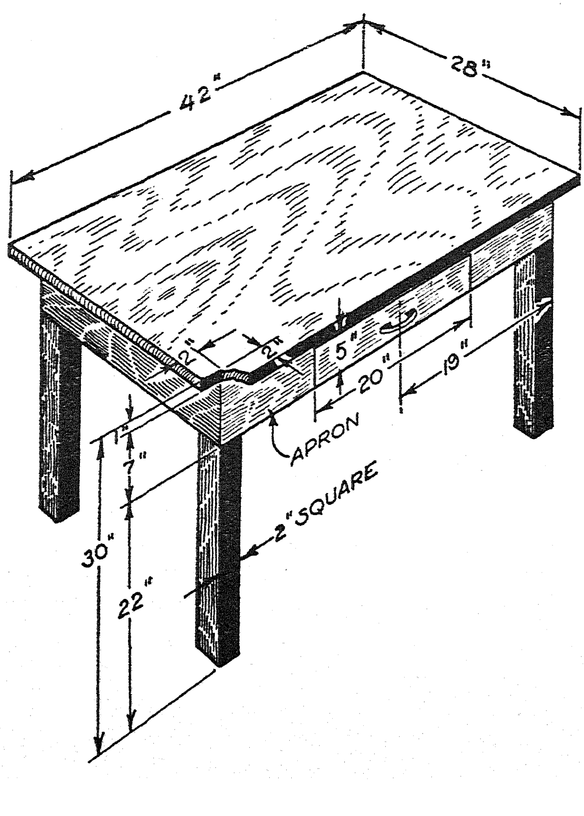
4. *Ability to read and make working drawings for planning and constructing useful projects typical of modern industry.*

Mastery of understandings involved in Goal 4 is evidenced by the ability to make a working drawing for a new project or the ability to read a new drawing. The degree of understanding will be evident in

the speed and efficiency with which the boy or girl meets a new drawing problem. If the student organizes well, lays out the drawing accurately, shows the necessary view, uses the tools correctly, follows approved practices and dimensions, and letters well, there is reliable evidence that he has the understanding and the skills to make a good working drawing. On the other hand, if the student does the lay-out of the drawing in ink, places the three views parallel, makes inaccurate measurements, and smudges the drawing with dirty hands, there is evidence of inadequate understanding.

Some evidence of understanding in reading working drawings or in making them can be obtained by test exercises, problems, and scales. The following samples are suggestive for use in helping to evaluate the degree of understanding.

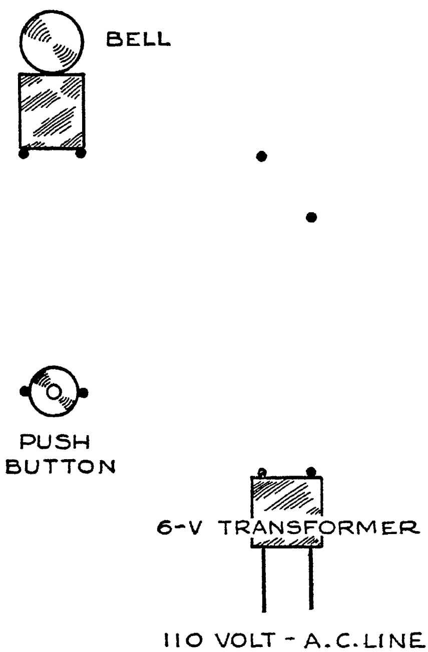
1. Make a half-size detailed drawing of a wrought-iron foot scraper showing the front, side, and top views.
2. Read the drawing of the table shown below and mark each of the following statements as true or false.



a.	The table is 30″ high.	True	False
b.	The table has a drawer 3″ deep.	True	False
c.	The legs of the table are 2″x2″x30″.	True	False
d.	The corner joints are mortise and tenon.	True	False
e.	The apron is 6″ in width.	True	False
f.	The drawer is 20″ wide.	True	False

Diagram Completion Exercise

The diagram-completion type of test question is helpful in determining amount of understanding. In the accompanying illustration the understanding to be measured relates to wiring electrical circuits. The directions are to draw lines between the black dots to show the electrical circuit which will permit the bell or buzzer to operate independently. A perfect score is eight points, or one point for each correct connection.



Multiple-Choice Items

A graded series of exercises might be prepared in each of which a working drawing is shown at the left and four perspective or ortho-

graphic drawings of three-dimensional objects are shown at the right, with the pupil invited to choose the three-dimensional view that corresponds to the working drawing.

Evaluation Scale for a Mechanical Drawing

The evaluation of a pupil's drawing with a rating scale will help the instructor determine the pupil's understanding. Some of the ratings, such as those indicated below, will help the pupil increase his understanding of drawing by helping him to learn the items basic to a good drawing.

Directions: The information required to evaluate the items is obtained by inspection and physical measurement. Each item is evaluated on the basis of 10 points. The total evaluation of the drawing is the sum of all the item evaluations which apply to the drawing.

1. *The placing on paper:* 1 2 3 4 5 6 7 8 9 10
   Is the object placed in such a manner as to permit a clear-cut drawing?
2. *Dimension lines:*
   a. Placing: 1 2 3 4 5 6 7 8 9 10
   Are the lines placed correctly and conspicuously?
   b. Quantity: 1 2 3 4 5 6 7 8 9 10
   Are the necessary lines in?
3 *Dimensions:*
   a. Legibility: 1 2 3 4 5 6 7 8 9 10
   Can the lines be read?
4. *Notations:*
   a. Legibility: 1 2 3 4 5 6 7 8 9 10
   Can the notes be read?
   b. Clearness: 1 2 3 4 5 6 7 8 9 10
   Do the notations state exactly what is wanted?
5. *Summing up the drawing:*
   a. Utility: 1 2 3 4 5 6 7 8 9 10
   Can the drawing be used?
   b. Value: 1 2 3 4 5 6 7 8 9 10
   Is the drawing of any aid in making the project drawn?

5. *The ability to choose industrial products with reference to design, pleasing color combinations, and durability; and to maintain and service such products.*

The understandings implied in the statement of Goal 5 will be evidenced by the pupil's ability to select wisely the products of industry for use in the school, the home, and the community. A boy who buys a bicycle because it has streamlined fenders, a speedometer, and a tail light, but fails to notice that the tires are undersize and the frame weak

and poorly constructed, shows little evidence of understanding; likewise the girl who buys a pretty dress but fails to notice that the seams and button holes are poorly made and that the material may fade rapidly in sunlight.

The achievement of the understandings included in Goal 5 may be at least partially evaluated through interviews, rating of industrial products, and test questions.

Rating of Products

Give the boys and girls four or five items like vacuum cleaners, door bells, radios, or chairs. Select the items so that some are of very good quality and others poor or average. Ask the students individually to rate each item as to quality and value. Students who usually select the best items show evidence of understanding as called for in Goal 5.

Test questions of the following types are helpful in determining whether or not understanding is being attained. Also, they are useful teaching devices for promoting an interest in the quality, operation, and design of industrial products.

Essay-Type Questions

1. Describe what construction features you would look for when buying the following articles. In each case tell *why*.

   An umbrella
   Baseball mitt and glove
   Baseball bat
   Tennis racquet
   Bicycle

2. Name five important points to be examined when purchasing an end table and explain their importance.
3. List five kinds of wood used in furniture and name parts of a piece of furniture where they are likely to be used and why.

Multiple-Choice Items

1. In selecting an assortment of desirable woodworking tools, which of the following items is most important?
   a. Wrench
   b. Compass saw
   c. Plane
   d. Hacksaw
   e. Center punch
2. Which of the following woods is not used in constructing good quality furniture?

a. Cherry
b. Birch
c. Maple
d. Hemlock
e. Gumwood

3. In using electrical equipment, which of the following practices does not result in using less electrical energy?
   a. Playing the radio softly instead of loudly
   b. Boiling vegetables slowly instead of rapidly
   c. Opening the refrigerator door as infrequently as possible
   d. Doing as much ironing as possible at one time

6. *Growth in abilities and attitudes related to mathematics, science, and the language arts, and to work habits, safety practices, and co-operation with others.*

The understandings implied in Goal 6 should be evident in all phases of the school program. If boys and girls write themes on industrial subjects for the English class, using technical terms intelligently, and if they work out problems in mathematics related to machines, or illustrate fundamental principles of science with machines or tools, there is evidence of fundamental understandings in the area of industrial-arts work.

Observation, interview, analysis of pupil's work in other classes, and the use of test items and rating scales are all of some value in the measurement of understanding of the types called for in goal six. The following test items and the sample rating scale will be of value in determining the amount of understanding the boys and girls have achieved.

Multiple-Choice Items

Indicate by check mark the word or words which complete each sentence correctly.

1. Knots in lumber are caused by
   a. boring insects.
   b. branches.
   c. winter injury.
   d. decay.
   e. unequal growth.
2. A bimetallic thermostat operates because
   a. metals expand when heated.
   b. different metals expand at different rates when heated.
   c. two metals will conduct electric currents at different rates.
   d. a voltage is produced between the junctions of the two metals when one junction is heated.

True-False Test Items

Mark each statement to indicate whether it is true or false.

1. The principle of the electromagnet is fundamental in motors and generators.
2. The two-cycle gasoline engine is most frequently used as the source of power in American-made automobiles.
3. Frequency modulation is the newest type of amplifier used in radio receivers.
4. Jet propulsion requires an expensive, highly refined fuel.

Example of Rating Scale

Boys and girls should have a good personality if they are to work effectively with others or assume positions of leadership. Commonly used methods for gaining an understanding of personality are free association, direct observation of behavior, rating scales, and personal reports. Rating scales are of most value when the user is well acquainted with the person being rated. The following personality rating scale will help the teacher and pupil to understand some of the factors that are important in a good personality as it relates to success in industry. If a boy or girl has a high rating, it is one indication that he or she is developing an understanding of correct work habits and is efficient in working with other associates.

Minimum				Average					Maximum
				Self-Reliance					
Does the pupil plan his work carefully and thoughtfully?									
1	2	3	4	5	6	7	8	9	10
Does the pupil conduct the work with only necessary help?									
1	2	3	4	5	6	7	8	9	10
Does the pupil ask for help when the problem is too difficult?									
1	2	3	4	5	6	7	8	9	10
				Work Habits					
Is the pupil in the habit of doing careful and thoughtful work?									
1	2	3	4	5	6	7	8	9	10
Does he loiter or waste time in his work?									
1	2	3	4	5	6	7	8	9	10
				Readiness To Assume Responsibility					
Is the pupil willing to undertake a worth-while task even though it is difficult?									
1	2	3	4	5	6	7	8	9	10
Does the pupil finish all his work?									
1	2	3	4	5	6	7	8	9	10

Punctuality

Does the pupil arrive on time at classes?

1 2 3 4 5 6 7 8 9 10

Does the pupil hand in his work on time?

1 2 3 4 5 6 7 8 9 10

Co-operation

Does the pupil help others when help is needed?

1 2 3 4 5 6 7 8 9 10

Is the pupil active in group undertakings?

1 2 3 4 5 6 7 8 9 10

Consideration of Others

Does the pupil have the habit of making things pleasant for his classmates?

1 2 3 4 5 6 7 8 9 10

Does the pupil help keep the shop in order?

1 2 3 4 5 6 7 8 9 10

Does the pupil put away tools in the right places?

1 2 3 4 5 6 7 8 9 10

When the whole class is involved in some work does he do his share or skip away?

1 2 3 4 5 6 7 8 9 10

Cleanliness and Neatness

Does the pupil keep himself washed clean?

1 2 3 4 5 6 7 8 9 10

Does the pupil dress neatly and in good taste?

1 2 3 4 5 6 7 8 9 10

Does the pupil do neat work?

1 2 3 4 5 6 7 8 9 10

Optimistic View of Life

Does the pupil have a natural and cordial smile?

1 2 3 4 5 6 7 8 9 10

Does the pupil complain about his lot in life?

1 2 3 4 5 6 7 8 9 10

Is the pupil liked by his classmates?

1 2 3 4 5 6 7 8 9 10

The devices here described are merely illustrative of the variety of testing and observing procedures which teachers will find helpful in evaluating pupil understandings related to Goal 6. It is the consensus of this committee that the continuing use of such devices will serve to direct the attention of both teachers and pupils to many valuable outcomes of instruction which may be attained in the field of industrial arts.

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SECTION III

A FORWARD LOOK

CHAPTER XVII

NEXT STEPS

THE YEARBOOK COMMITTEE

To a considerable extent, the "next steps" to be taken to improve the measurement of understanding in the school have been foreshadowed in the theoretical content of Section I of the yearbook. To some extent, too, these "next steps" are implicit in the illustrative procedures exhibited in Section II. Even so, here at the end of the volume it may be well to detail a few specific things-to-be-done as a means of making more concrete the program of betterment.

1. *There must be a more general acceptance of the school's responsibility for developing and measuring growth with respect to outcomes which involve understanding—a more general acceptance together with a real attempt to do something about it.*

It is highly probable that for several decades every national committee on the teaching of the various school subjects has included in its list of objectives statements which relate to understandings. It is equally probable that during this same period every good professional textbook on the teaching of the school subjects and every good professional course in this area have called attention to understandings as critically important objectives. In a word, educational *theory* has consistently given prominence to the necessity of cultivating understandings through instruction.

The same statement cannot be made, however, with regard to *practice* in classroom instruction. While there is plenty of evidence of a growing recognition of the role of understanding in the learning process, it is a fact that in our teaching we are still prone to pay lip-service to understandings as educational aims. In this respect understandings occupy about the same place as does "character building." We ex-

press our concern about understandings, as we do about character building, but if they—and sound character—are achieved, it is largely by incidental, if not accidental, means. We may be sure that until we remedy our neglect and actively and deliberately undertake an appropriate program of vigorous instruction, understandings, like character, will continue to suffer.

By the same token, we shall have to commit ourselves seriously to the evaluation of understandings. We cannot forever delude ourselves with the idea that our children are really achieving understandings (as they may be doing, to be sure), whether or not we evaluate their understandings; nor should we indulge the equally comforting notion that we evaluate understandings when we test for proficiency in mechanical skills or for command over assigned verbalizations. There is too much research evidence already at hand and too much evidence from common-sense observation to warrant our continued repose in this fool's paradise. We will do well to shake off our false notions and to face reality. Then, as has just been stated, we shall actually accept responsibility for measuring understanding and we shall do something about it.

At this point a caution may not be out of place. When we begin systematically to assess understandings, we must be prepared to alter some of our ideas about evaluation. Among these ideas is that of the conventional "passing mark" as a criterion of satisfactory performance.[1] In the case of essential knowledge and skills (e.g., the simple number combinations in arithmetic) we are accustomed to set the passing mark very high, at 95 perhaps (some would say 100) on a percentage scale. No such close approximation to perfection is to be expected in the case of many understandings. Inclusion of but a few items which call for understanding in a test which is devoted otherwise to simple factual questions will make that test "too hard" in terms of a fixed passing grade. If we hold to our present passing grade, we must then limit our measurement of understandings to the simplest and most elementary. To do so would be a poor bargain, for we should be

[1] This caution is not "new." Indeed, it has been specifically discussed by careful builders of standardized tests on more than one occasion. (See, for example, *Manual for Interpretation of Iowa Every-Pupil Tests of Basic Skills,* Form M, pp. 22-25. Boston: Houghton Mifflin Co., 1941.) As in many other places throughout the yearbook, this particular caution is inserted here because the idea, namely, of a reconsideration of passing marks, has not worked its way very far into the thinking of school people. It needs to be repeated that this yearbook is intended for the practical classroom teacher; hence, it contains little, if anything, that will be regarded by measurements experts as representing innovations in theory or practice.

evading our responsibility. There is another way out, and that is to set varying passing marks in order to allow for differences in the depth, extent, and complexity of the understandings under evaluation. The second alternative would seem to be the preferable procedure.

2. *The understandings which are essential to each subject-matter area need to be identified and to be made intelligible to teachers.*

Obviously, if teachers are to measure (and to teach) understandings, they must first know what these understandings are. They are not always equipped with this knowledge. Sometimes, indeed, they themselves lack the essential understandings. Sometimes, on the other hand, they possess the understandings and actually use them in their behavior, but do not recognize them as such. Many primary-grade teachers, for example, think that the ability to furnish "eight" or "8" in response to the question, "How many are five and three?", is all that is involved in knowing the fact, $5 + 3 = 8$. And why not? Do they not, themselves, think "eight" at once in these situations, and do they not do so "without thinking," which is to say, without making use of meanings and understandings? Such may seem to be the case, but it is not true to fact. Parrots can learn to say "eight" when asked, "How many are five and three?" But parrots cannot do arithmetic. Evidently parrots lack something, and that something is a store of related meanings.

Whether teachers lack essential understandings or have them without being conscious of the fact, the evaluation of understandings must necessarily suffer. The first step in correcting the evils of the situation is to identify those critical understandings which teachers must possess and the presence (and absence) of which they must be able to recognize in the behavior of their pupils. This process of identifying critical understandings has been under way for some time. (Witness the lists of objectives which involve understanding in the chapters of Section II of this volume.) But the process must be continued and extended in all subject fields. If they are to be intelligible, the understandings which are isolated must be stated simply and illustrated clearly. When such statements are incomplete or ambiguous, there will be the need to describe in some detail the behavior of children who have acquired the understandings in question. The responsibility here falls alike on subject-matter specialists, research workers, writers of textbooks, instructors in courses in the preparation of teachers, and supervisory agents in the public schools in charge of the in-service training of teachers.

3. *Teachers' confidence in their ability to assess evidence of understanding, a process which is necessarily subjective, must be strengthened.*

It would hardly misrepresent the situation to substitute the word "restored" for "strengthened" in the proposition above and to say that teachers' confidence in their ability to evaluate understanding on the part of their pupils must be restored. Certainly during the first quarter of this century their confidence in their judgment was seriously undermined. Study after study was made, the results of which were interpreted to mean that teachers' judgments concerning their pupils' learning are practically worthless. And the textbooks on educational measurement which appeared in those years reiterated the notion. Quite commonly the opening chapters of these texts were devoted to an attack upon teachers' marks and estimates of ability, as a springboard for advocating the general adoption of "objective" tests, preferably standardized.

This is not the place to canvass these studies or to examine the conclusions in any thorough-going manner. However, two pertinent facts worthy of mention have emerged from the research and the critical thinking of the past fifteen years or so.

(*a*) So-called "objective" measurement has turned out to be not so very objective after all. True, once a key has been prepared for a given true-false or multiple-choice or other new-type test, the scoring is objective in the sense that all competent persons who use the key accurately secure the same score for the same test paper. But subjective factors continue to pervade the testing situation—in the decision as to type and length of test, the scope of the test, the selection of test items, the wording of the items, the ordering or arrangement of the items in the test, the method of administering the test, the preparation of the test key, the transmutation of test scores into marks or grades, and so on. In a word, judgment, instead of being eliminated from the evaluation as has been said or implied by more than one measurements expert, still plays a dominating role, and it will inevitably continue to do so. The function of good measurement is not to substitute for judgment, but to insure that judgment is based on adequate and dependable data.

(*b*) The careful judgments of expert teachers have been found to approximate very closely the reliability of measures obtained by so-called objective instruments. (And as for validity, such judgments may well surpass "objective" tests by a very wide margin.) The crucial words in the first sentence of this paragraph are of course "care-

ful" and "expert." Casual judgments, even of expert teachers, are untrustworthy; so are many of the judgments, careful or otherwise, of inexperienced teachers.

For the present purpose the import of the two foregoing paragraphs is the same. If judgment operates in all evaluation, even with "objective" tests, and if judgment, when exercised carefully and expertly, can be trusted to evaluate understanding, then the problem is chiefly one of improving teachers' ability to judge and of encouraging them to employ their improved judgment more generally and more confidently. Once teachers accept the responsibility to evaluate understanding (proposition 1) and once they know what understandings they are to evaluate (proposition 2), then they will need much help in developing sound techniques to assure careful, expert judgment, regardless of the particular means (paper-and-pencil tests, observation, etc.) employed. There is plenty of opportunity here for real service on the part of all who undertake to prepare teachers for their professional activities and to foster their growth in that profession.

4. *Teachers must learn what kinds of behavior signify the attainment and the nonattainment of outcomes which involve understanding and must learn the conditions under which this behavior may be so interpreted.*

So far as measurement is concerned, understanding is assumed to be evidenced by some kind or kinds of behavior. This behavior may take varied forms, that of written or oral language, emotional responses, overt motor adjustments, and so on. To make these forms of behavior serve the end of evaluating understanding demands ability to discriminate between behavior that is based upon understanding and behavior that is not. And in very few cases is understanding, or lack of it, so obvious that "he who runs may read." To complicate matters further, the same overt behavior may or may not be evidence of understanding, depending upon the conditions which elicit it. And again, these conditions may be in the external situation or they may involve such internal factors as the purposes or "set" of the learner.

The sort of discrimination called for in order to judge the degree of understanding accompanying observed behavior is, therefore, not easy to make. Yet, the insights and skills involved in this discrimination, like other insights and skills, are susceptible to improvement. Many teachers, now inexpert in such discrimination, can become competent. One of the major tasks of teacher preparation and of in-service aid to teachers is to develop this competence.

Obviously the first step is to make sure that teachers themselves possess the understandings which are to be taught and evaluated. If, in teacher preparation, this means more learning time for their subject areas, then the time must be found in their course programs, even if this means less time for the "tricks of the trade" or a larger total time devoted to preparation. The second step is to provide opportunity for and skilled guidance in analytical observation. Some opportunity for observation is usually provided; most prospective teachers "observe" classroom instruction even prior to actual practice teaching. But the skilled guidance is not furnished so often. Too frequently prospective teachers "observe" teaching (someone else's and their own) without knowing what to look for in pupil behavior and without having the benefit of a later critical appraisal by the instructor in charge. The tendency, when there is appraisal at all, is to concentrate on the merits and the weaknesses of the teacher's activities, with a consequent neglect of significant behavior on the part of pupils. A high level of skill cannot be developed in the limited time conventionally allowed for "observation and practice teaching."

Teachers in service can likewise profit from training in analytical observation. Supervisors may well turn their attention, in larger measure than is common, to encouraging teachers to note evidence of understanding and of nonunderstanding in the things their pupils do and say. To offer one concrete suggestion: Especially competent teachers, temporarily relieved from some of their other duties, might work together under expert guidance to prepare tests and to write instructions for measuring understanding in their particular fields, the results of their efforts then being shared with the teaching staff as a whole.

5. *In looking for evidence of understanding there is a need to broaden the base of the observations by employing evaluative procedures which go beyond the usual kinds of paper-and-pencil testing.*

This statement is not a call for the wholesale abandonment of paper-and-pencil tests to measure understanding. True, in several places in this yearbook, especially in chapter iv, the limitations of such instruments have been stressed. Many of these limitations arise from the fact that language behavior, whether in written tests or otherwise, may be equivocal with respect to the presence or the absence of understandings. Correct responses may be no more than the glib repetition of empty verbalizations or the correct identification of phrases which are devoid of meaning. Yet, in spite of their limitations, paper-and-pencil tests are of unquestionable value in measuring understandings. This fact has been amply demonstrated by the illustrative procedures

of Section II of this volume. The point of proposition 5 is, then, that such paper-and-pencil tests, improved as much as they can be, still need to be supplemented by other procedures, procedures which will expose aspects of understanding (or the lack thereof) which are not explored by written tests.

These supplementary evaluative procedures have been described and abundantly exemplified in the earlier chapters of this volume. In general, they are based upon observation in some form or other—systematized and unsystematized, oral questioning and the recording of significant episodes, rating scales and check lists. They differ fundamentally from written tests, both in the situations which evoke the behavior and in the behavior itself. They are likely to differ also in the freedom of the response which is permissible, as well as in its complexity.

Like written tests, these procedures also have their limitations which have been pointed out many times in the literature. They are usually time-consuming, with the result that adequate sampling is laborious. Their use demands, as has been noted, some expertness on the part of the observer. Finally, because of the equivocal nature of behavior itself, their interpretation is not always easy. To call attention to the limitations of these non-test procedures is not, however, to deny their positive values. Knowledge of their limitations should serve only to make us careful in planning the procedures and in interpreting what we discover through their use.

If adequate knowledge regarding status and progress in understanding is to be had, the program of evaluation must be comprehensive enough to ensure the collection of all crucially relevant evidence. In part, this evidence can be secured from paper-and-pencil tests which have been specifically designed for the purpose. But to limit the evaluation program to written tests, "objective" or otherwise, however "good" they may be, is to disregard other essential means of getting information. It is for this reason that in the theoretical chapters of the yearbook teachers were encouraged to take full advantage of the day-by-day happenings in the classroom and in the school as a whole, to confer with individual children and with groups of children, to examine the work products of their pupils, to pay particular attention to the answers given by children in response to questions and to the questions which they themselves ask, and to keep anecdotal records of children's normal and unusual activities which manifest understanding. It was for this reason, too, that the committees in charge of the chapters of Section II described so many ways, besides written

tests, in which to assess children's behavior for its content of understanding. And it is for this same reason that here in the last chapter of the volume a final opportunity is seized to urge teachers to broaden the base of their evaluation, to the end that understanding may be more comprehensively measured.

6. *Research must be undertaken to improve many evaluative procedures and techniques which are now employed spasmodically, clumsily, and uncertainly.*

Such conventional devices as the true-false, multiple-choice, and completion tests have become more and more useful as they have been subjected to scientific study, and the amount of research that has been done concerning these devices is considerable. On the other hand, many of the promising techniques for getting data from which understanding, or a lack of it, may be inferred, have not been so carefully and so extensively investigated. Even the much-used essay examination has been the object of much more criticism than of painstaking study concerning its possible improvement. A few studies on the use of anecdotal records have been made; but there is almost a complete lack of research relating to the use of many techniques and evaluative procedures which have been mentioned throughout this yearbook.

What is needed is research to develop and to test techniques for collecting, systematizing, and interpreting observations and records of pupil behavior where this behavior is relatively free and extended and is engaged in without conscious intent to meet a "test" situation. Dependable inferences concerning a child's understanding can be made from such data only when procedures of known dependability are available for handling the data. Until we have this knowledge, we shall be limited to such vague exhortations to teachers as: "Determine through creative drawings the understanding of children"; "Through informal observation ascertain the extent to which students assume responsibility"; "Examine the written work of your pupils"; "Have the children keep diaries"—all this for the reason that teachers do not know, nor do "experts" as yet know too well, how to get trustworthy information on understandings from such data.

There is every reason to believe that competent research on non-test evaluative procedures will yield results as fruitful as those which have followed from the investigation of "objective" tests. Moreover, the results of studies of similar problems in fields allied to education are encouraging. To mention only a few: The extensive research on projective techniques, the refinements of procedures for measuring public opinion made by such men as Cantril and Lazarsfeld, the methods

of collecting and systematizing data in use by many cultural anthropologists, the techniques for more effective interviewing developed originally by Wonderlic and Stevens—all are suggestive of leads that may be found useful for getting evidence related to children's understanding. Perhaps the technological developments resulting from adequate research in this field of educational appraisal will eventually lead even to our being able to *count* the "outcomes" in these complex data and in much the same manner as is now possible in our "objective" testing.

7. *Textbooks on classroom evaluation must give more attention than is commonly given to the need for evaluating understanding and to the procedures suitable for this task.*

For the past several decades the education of prospective teachers and of teachers in service respecting the problems of measurement has been based pretty largly upon textbooks on measurement. There is every probability that this practice will continue. On this account a heavy responsibility has been imposed and is still imposed upon these texts and upon their authors—a responsibility which, as has been repeatedly pointed out in this yearbook, has been none too well met.

It is perhaps natural that in the early days, when "objective" test techniques were relatively new, the major emphasis in measurement texts should have been placed upon "objective" procedures. It is also natural that, in making a case for them, writers of these texts dwelt upon the shortcomings of the evaluative procedures then in vogue. Natural or not, this is precisely what happened, and it was not uncommon to find two-thirds or more of textbook space devoted to "objective" tests (especially standardized tests), with directions for their construction, administration, and scoring, for the statistical treatment of test data, and for the use of the scores or other measures which eventuated. Meanwhile, teachers who used standardized tests rarely, if at all, but who nevertheless day by day faced the problem of evaluating learning in some way were left with little help, save, as has been noted, in the matter of "objective" tests.

In these circumstances it is small wonder that evaluation was restricted to testing, that testing was restricted to paper-and-pencil instruments, and that these instruments were restricted to those which were "objective" in form. And it is small wonder that understandings as learning outcomes were neglected. Textbooks on measurement scarcely mentioned them; and when they did, they offered few suggestions for their evaluation. On their part, teachers—having been denied the use of their traditional "subjective" procedures for evalu-

ation (classroom questioning and observation, the essay test, etc.), and finding it difficult to adapt the new test forms to the evaluation of understanding—came to concentrate on the measurement of isolated facts and mechanical skills.

All this, it is to be hoped, is soon to be a matter of history. Certainly there are welcome signs of change in the newer textbooks. To be mentioned are: a tendency to extend the concepts of measurement and evaluation to include all learning outcomes, explicit recognition of outcomes which involve understanding, attempts to show how "objective" techniques may be employed more effectively to get at these outcomes, frank advice to teachers to employ evaluative procedures other than written tests, and some suggestions for the refinement and improvement of these latter procedures. These changes are all healthful; they are in the right direction, and they should be encouraged. If these trends continue, textbooks on educational measurement will meet much more satisfactorily the responsibilities assigned to them, and teachers, both those in preparation and those in service, will know better how to obtain evidence of understanding. More than that, they *will* obtain this evidence, thereby improving their teaching and assuring sounder and more worth-while learning on the part of children in their charge.

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INFORMATION CONCERNING THE NATIONAL SOCIETY FOR THE STUDY OF EDUCATION

1. Purpose. The purpose of the National Society is to promote the investigation and discussion of educational questions. To this end it holds an annual meeting and publishes a series of yearbooks.

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